VOLUME 49 NUMBER 2

TERRESTRIAL MAGNETISM AND ATMOSPHERIC ELECTRICITY

An International Quarterly Journal

June, 1944

Founded by LOUIS A. BAUER
Conducted by J. A. FLEMING
With the Cooperation of Eminent Investigators

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PUBLISHED FOR
THE JOHNS HOPKINS PRESS, BALTIMORE 18, MARYLAND
THE RUTER PRESS, 420 PLUM ST., CINCINNATI 2, OHIO
THREE DOLLARS AND FIFTY CENTS A YEAR SINGLE NUMBERS, ONE DOLLAR

THE JOHNS HOPKINS PRESS
BALTIMORE 18, MARYLAND
Entered as second-class matter at the Post-office at Cincinnati, Ohio

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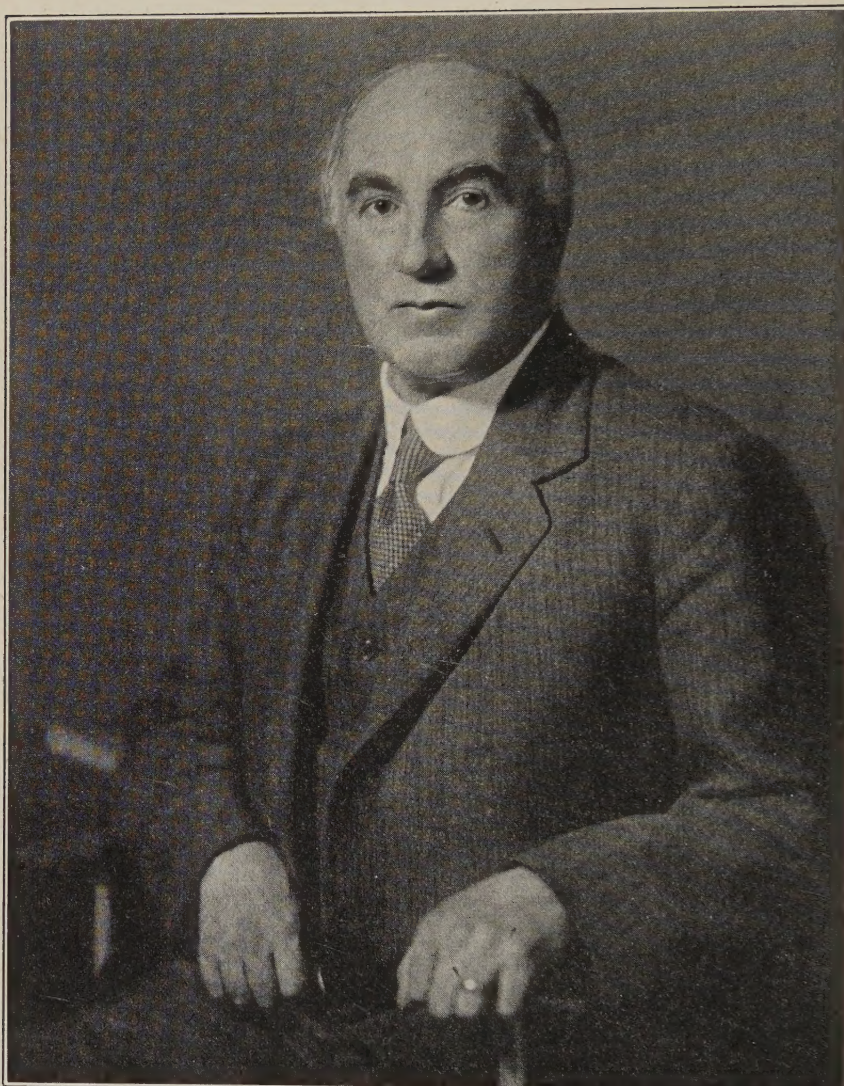

G C Whipple

Terrestrial Magnetism
and
Atmospheric Electricity

VOLUME 49 JUNE, 1944 No. 2

THE GEOGRAPHIC INCIDENCE OF AURORA AND MAGNETIC DISTURBANCE, NORTHERN HEMISPHERE

BY E. H. VESTINE

1—*Introduction*

Fritz [see 7 of "References" at end of paper] in a famous memoir published in 1881 discussed the frequency and characteristics of aurora observed in the Northern Hemisphere during the years 1700 to 1872. Using observations during this 172-year period [8] he also constructed his well-known map of isochasms of equal auroral frequency.

Beginning is made here in the statistical analysis of the auroral data since accumulated, a task of considerable magnitude if undertaken with any pretense at completeness. The present paper is concerned mainly with the variation with geographic position of the average daily frequency of aurora in high latitudes, and of geomagnetic disturbance.

Since 1872 much observational material has accumulated but there has been little statistical study of the geographic incidence of auroras on a world-wide scale. There have in fact been organized two great international expeditions to numerous points within auroral regions during the past 70 years, the so-called International Polar-Year expeditions of 1882-83 and 1932-33, providing extensive new material for use in these problems. During this same period also Birkeland [2], Störmer [14], Vegard [16], Krogness [17], Harang [11], and others, have made the study of aurora much of their life's work, greatly extending our knowledge of the phenomenon and of the atmosphere where it appears; in the course of this work they have likewise obtained and listed numerous observations of aurora. Additional extensive series of observations and valuable studies of aurora have also been made by Fuller and Bramhall [3, 9], Stagg [13], Currie [5], Davies [6], and others. A further source of data is furnished by the accumulated routine observations of meteorological and astronomical observatories, and those of universities and auroral observatories which sometimes include in addition the work of numerous voluntary and amateur observers throughout extensive territories. Finally, various characteristics of aurora have sometimes been continuously recorded photographically in recent years, notably by Vegard and Krogness [17], and Harang in Norway, Bramhall and Seaton in Alaska, and Gartlein in the United States.

Preliminary to the study of these data on the geographic incidence of aurora there would be required, as has been frequently suggested, but not yet attempted, the accumulation of data (possibly where necessary in the form of microfilm copies) at some adequately financed central bureau. Even though the data so collected would be somewhat hetero-

geneous, they would prove of great value in the discussion of certain statistical aspects of auroral displays.

One of the more obvious and simpler undertakings would be the extension of the systematic cataloguing of Fritz [8] for the past 70 years. There would then emerge some degree of homogeneity by virtue of the organization of the data, for instance as regards the prevalence of various auroral types in different latitudes, such as homogeneous arcs, bands, ray-arcs, glows, and forms rare in occurrence. Advantages afforded by improved distribution of stations and more systematic observational procedure would render the new data in some respects superior to that of Fritz. The daily variation of auroral frequency might also be derived in more complete form than in the determinations based on earlier data and examination made of its interesting changes with latitude and longitude, in extension of studies by Vegard, Hulburt, and others [4]. Finally, intercomparisons of more special results at the small number of stations available for this purpose might be attempted.

The description of various changes in auroral characteristics with position on the Earth seems likely also to be considerably facilitated by suitable consideration of the allied phenomena with which it is found associated. Of particular interest are the close relationships of aurora, ionospheric changes, and magnetic disturbance, particularly since the geographic distribution of the latter has now become more clearly defined through the work of Birkeland [2], Chapman and Bartels [4], and others.

2—*The isochasms of Fritz*

Figures 1 and 2 illustrate an application of this kind of information. In Figure 1 are given the isochasms or lines of equal observed frequency of aurora in days per year, as deduced by Fritz for the period 1700 to 1872, based on thousands of observations [7]. Shown also is a curve giving the average position of points with maximum disturbance in magnetic horizontal intensity for the disturbance daily variation as found by the writer for the average of disturbed days of the Polar Year, 1932-33 [18]. The isochasm of maximum auroral frequency and the auroral-zone curve derived from magnetic data are in good general agreement, except near the northeastern part of the Union of Soviet Socialist Republics, northern Alaska, and Canada. Examination of the data given by Fritz [7, 8] shows that he had available few observations of aurora in regions where the discrepancies are most marked; as will appear later the auroral observations at Ssagastyr during the First Polar Year, those of the *Maud*, and in recent years those at College, Fort Rae, and Meanook confirm as more satisfactory the auroral zone deduced from the geomagnetic data. Again, since the curve afforded by the geomagnetic data is derived from annual values for magnetic stations near the zone, it appears relatively well determined and therefore likely to afford a fairly satisfactory estimate of the position of the zone of maximum auroral frequency on moderately disturbed days.

Since Fritz did not take into account the influence of the variation from station to station in the number of cloudy nights interfering with observation of aurora if present, the isochasms of Figure 1 may be presumed roughly to give the frequency of aurora under conditions of cloudiness averaged along each isochasm. The careful correction of

the extensive data of Fritz for the influence of cloudiness on the recorded frequencies is scarcely possible, since the majority of observers did not systematically record nights too cloudy for the observation of aurora, a defect still sadly evident in much of the data since 1871. However, in view of the increased importance of auroral displays in affecting radio communications, particularly in higher latitudes, the actual incidence as compared with the observed incidence noted at ground-level is of considerable interest. It would also appear desirable that at least tentative estimates be available respecting the frequencies expected at the auroral zone (for which Fritz had little data) and for the isochasms inside.

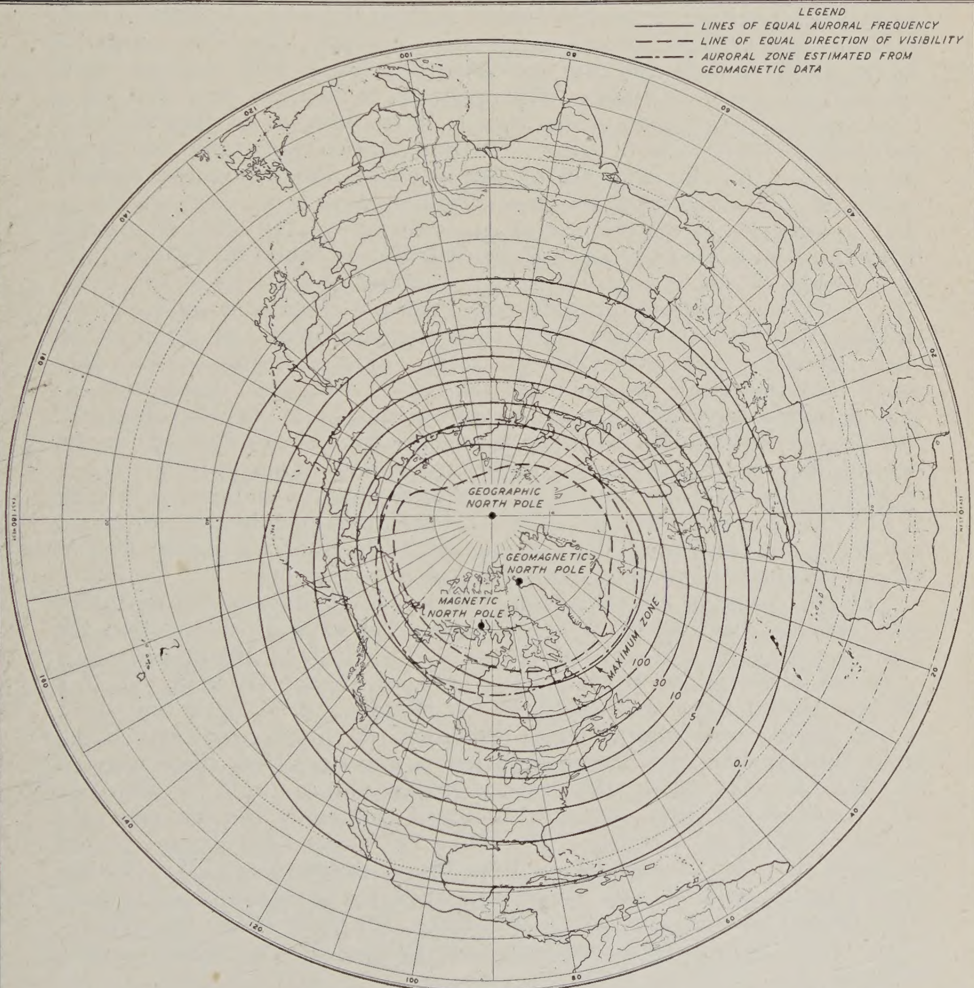

FIG. 1—AVERAGE ISOCHASMS AND LINE OF EQUAL DIRECTION OF VISIBILITY (AS DRAWN BY FRITZ) WITH ADDITION OF MAXIMUM AURORAL ZONE AS ESTIMATED FROM GEOMAGNETIC DATA (VESTINE)

The variation in auroral frequency with distance from the auroral zone can be examined by assuming that the isochasms near the zone have a fairly simple distribution, roughly parallel to those already derived. Adopting then this zonal-symmetrical distribution the frequencies found by Fritz reduced to the meridian 290° east (which passes very nearly through the geomagnetic north pole) may be conveniently considered. Figure 2 shows these frequencies of Fritz plotted as a function of geomagnetic latitude, the isochasm of maximum auroral frequency as afforded by the geomagnetic data being located along this meridian in geomagnetic latitude 69°.0 north.

The latitude-distribution so indicated corresponds to the general level of auroral disturbance appropriate to the data of Fritz. The frequencies appropriate to other years, such as those for the Polar Years, 1882-83, and 1932-33 are not necessarily the same, since there appears to be some variation in the incidence of aurora with sunspot-cycle, especially in lower latitudes. The apparent frequencies may also differ from year to year due to yearly change in the number of cloudy nights preventing observation of aurora. It thus appears preferable to correct the new data for the influence of cloudy nights where possible, seeking to obtain a fixed interval of observation in days with clear nights so that frequencies correspond to, or are reduced to, the level of auroral disturbance indicated by the latitude-distribution found for Fritz's data, the average of 172 years. Data for a number of stations of the Polar Year, 1932-33, were accordingly corrected for cloudiness, and the resulting proportionate frequencies so found multiplied by a factor to give a good fit south of the auroral zone. This procedure is obviously rough, but the points appear to fit the curve of Figure 2 fairly well, so that it is believed that a good first approximation is thereby obtained. In this way we obtain a basis for fitting the frequencies derived for the Second Polar Year to those appropriate to the level of auroral disturbance of Fritz. The data for the Polar Year were actually reduced to a year of 243 days to obtain this fit, so that as the basis of reduction we adopt say about one-third of all days of the year as unsuited for observation of aurora because of average cloudiness and other factors.

We next consider the reduction of high-latitude data to the tentative standard-year basis of $[(2/3)\times 365]$ days $=243$ days of observation for Fort Rae, Canada. Stagg and his party [13] obtained 249 observations of aurora in the period September 1, 1932, to August 31, 1933. Of this 365-day period there were 45 days too cloudy and 71 days too sunlit (a few spring and summer days excluded, daylight conditions being highly unfavorable) for the observation of aurora. Thus there were in all $(365-45-71)$ days $=249$ days on which aurora could be seen out of a possible 249 days, and our standard frequency for the standard period of 243 days becomes $[(249/249)\times 243]$ days $=243$ days. It will be noted that this means auroras were visible every clear night. In the same way during a 212-day observational period at Saskatoon, Canada, there were observed auroras on 39 nights, 101 days being too cloudy, whence for the standard frequency we obtain $[(39/111)\times 243]$ days $=$ 85 days.

Unfortunately a procedure of the foregoing kind is in general applicable to only a small number of the stations observing aurora during

the past half century, because of incomplete records of cloudiness. It is hence necessary to consider in somewhat greater detail and varied manner the adjustment of auroral data to a common basis of cloudiness, general observing conditions, and epoch.

3—*The effect of cloudiness and daylight-conditions on the observed frequency of aurora in high latitudes*

The visual observation of aurora when present is frequently impossible because of cloudiness, which obstructs the view of aurora by eye, and also because of daylight, in which case the aurora cannot be seen because of insufficient contrast. Thus the number of days per year on which aurora appear above any given locality is not specified by the number of days per year on which there has been visual evidence of the presence of aurora. There can hence be obtained at best only an estimated value of the true frequency of occurrence of aurora, on the basis of more or less plausible corrections for cloudiness or daylight-conditions.

Near the zone of maximum auroral frequency, where the number of days with aurora does not seem to vary appreciably with season or sun-spot-cycle, even though there be systematic time-changes in the average intensity, the number of days per year on which aurora occur can probably be estimated rather accurately. It is only necessary to note the proportion of days with aurora observed on sufficiently dark and clear nights and adjust to a 365-day basis. The longer the period covered by such observations the closer will be the approximation to the true frequency for a given epoch.

When the series of observations near the auroral zone is short, say only a few months, it may be preferable to attempt corrections for cloudiness on the basis of cloudiness amounts sometimes available hourly, three-hourly, or eight-hourly in the course of routine meteorological observations at a station.

The elimination of the effects of cloudiness on observed frequencies of aurora according to day or hour is rendered comparatively difficult by the non-uniform incidence of cloudiness with geographical position of an auroral station. The amount of cloud varies not only with the year but also with time of year and day, and the corrections applied for each station must be considered individually.

Figure 3 shows the percentage of hours with aurora for hours of various amounts of cloud 0 to 10 at Fort Rae, during the observing hours of the period September 1, 1882, to August 31, 1883. Shown also are the total number of hours with the amounts of cloud 0 to 10 during the night hours suited to auroral observation during the period.

It would appear from the figure that the average percentage-frequency of observation of aurora per hour diminishes rapidly, more slowly at first, with increasing amount of cloud. Thus aurora appeared at Fort Rae on 71 per cent of all cloudless or practically cloudless hours, on 38 per cent of the hours with cloud-amount 6, but on only 2.5 per cent of the hours with cloud-amount 10. The fact that aurora were observed at all on hours of cloud-amount 10 is probably due not only to thinness of cloud-layers but also to the fact that the amount of cloud is

read at the exact hour. A small break in the clouds during the hour would occasionally permit observation of the sky above over a path traversing the entire sky. It will be noted that hours with cloud-amount 10, with 900 cases, appear most frequently but are accompanied by only five cases of aurora; the second largest number of cases is for cloud-amount zero with 766, with 548 hours of aurora, whereas hours with cloud-amounts five and six appear least frequently. Examination also

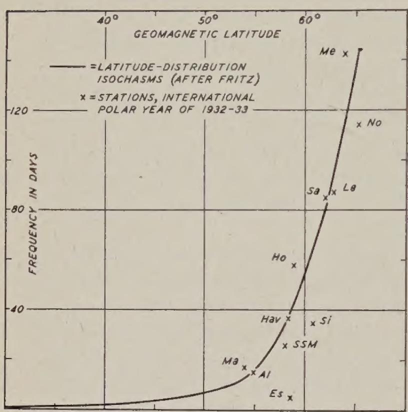

FIG. 2—COMPARISON FRITZ'S LATITUDE-DISTRIBUTION OF ISOCHASMS ALONG MERIDIAN 290° EAST WITH DATA FROM SECOND INTERNATIONAL POLAR YEAR 1932-33, ALL ADJUSTED TO CIRCULAR AURORAL ZONE IN GEOMAGNETIC LATITUDE 69° NORTH

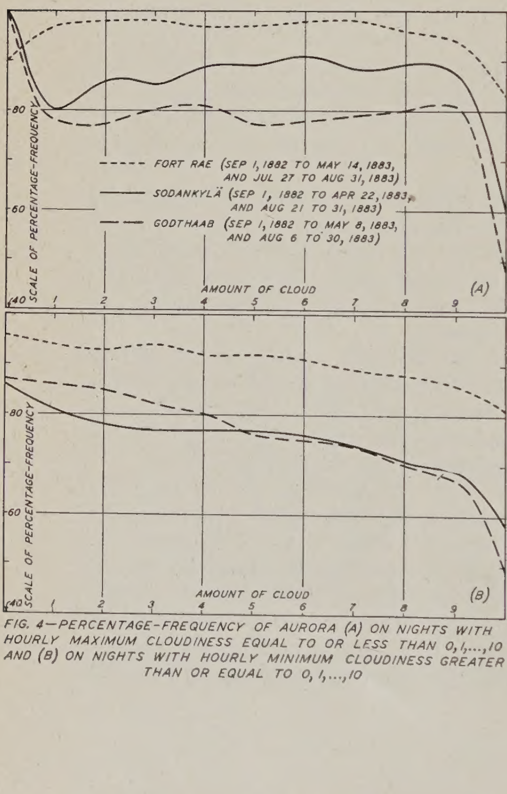

FIG. 4—PERCENTAGE-FREQUENCY OF AURORA (A) ON NIGHTS WITH HOURLY MAXIMUM CLOUDINESS EQUAL TO OR LESS THAN 0, 1,...,10 AND (B) ON NIGHTS WITH HOURLY MINIMUM CLOUDINESS GREATER THAN OR EQUAL TO 0, 1,...,10

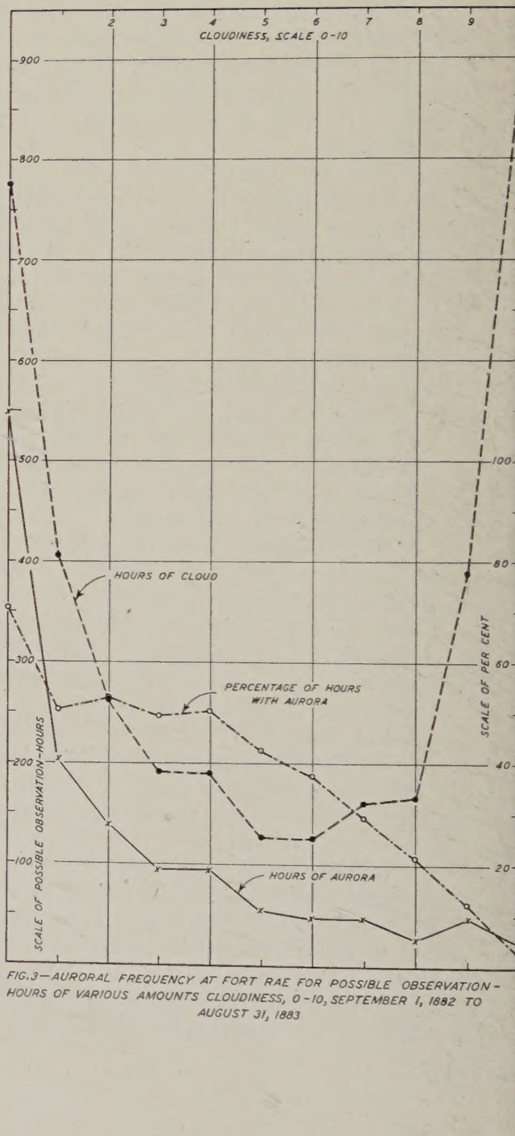

FIG. 3—AURORAL FREQUENCY AT FORT RAE FOR POSSIBLE OBSERVATION-HOURS OF VARIOUS AMOUNTS CLOUDINESS, 0-10, SEPTEMBER 1, 1882 TO AUGUST 31, 1883

shows that the average diurnal variation of cloud-amount is small (in general less than one unit of amount at Fort Rae). Thus the foregoing results are not likely to be affected much by the variation in cloud-amount with time of day. It is also interesting to note that at Fort Rae aurora have been observed on 100 per cent of all otherwise suitable clear nights whereas only 71 per cent of clear hours evince visually observed aurora (84 per cent for clear hours near geomagnetic midnight); this is a consequence of clear or nearly clear hours tending to be followed by other clear or nearly clear hours, and the increase per hour near midnight is due to the increased probability of aurora at that time.

Figure 4 shows in another way the dependence of auroral frequency on cloud-amount. In (A) of Figure 4 is shown the percentage-frequency of aurora on nights having only the various hourly cloud-amounts of 0, $\leqslant 1$, $\leqslant 2$, . . . , for the stations Fort Rae, Godthaab, and Sodankylä, during available dark observing hours. These results indicate that the effect of hourly amounts of cloud on observing days has little average influence until the amount of the maximum hourly cloud-amount exceeds seven. Thus at these three high-latitude stations a good estimate of the percentage-frequency of aurora is afforded by noting the number of observations of aurora during a total number of observing nights with hourly amounts of cloudiness not in excess of seven; thus from the figure the probable percentage-frequencies of aurora are about 100, 91, and 81, for Fort Rae, Sodankylä, and Godthaab, respectively. In (B) are shown the corresponding results for hourly cloud-amounts $\geqslant 0$, $\geqslant 1$, ... , indicating need for a percentage-correction if, say, days with hourly cloud-amounts in excess of seven are excluded.

Results of the foregoing kind do not establish a basis for correction of visual observations at other stations, unless the kind of clouds and their frequencies are sufficiently similar. Thus there may and do occur more frequently at some stations than at others clouds such as cirrus, which may not interfere appreciably with auroral observation whereas nimbostratus clouds may be expected to interfere in much the same manner with auroral observations at all stations. However, data of the foregoing kind can be used in various ways in the tentative correction of the observed frequency of aurora for the influence of cloudiness. Thus for Fort Rae in similar manner from tables of average daily amounts of cloud it was found that aurora were observed on 98, 91, and 65 per cent of days of daily average cloud-amount 0 to 2.5, 2.6 to 7.5, and 7.6 to 10, respectively. At Ssagastyr (see Table 2) during the 182-day period October 1, 1932, to March 31, 1933, from cloudiness tables there were 74, 27, and 81 days with cloud-amounts 0 to 2.5, 2.6 to 7.5, and 7.6 to 10, respectively. On the basis of these data for Fort Rae we may hence estimate the expected observed frequency of aurora at Fort Rae if the average amounts are those noted at Ssagastyr. This assumes equal transparency per average amount of cloud at both stations, and further that aurora occur every day at Fort Rae. We thus obtain $[(0.98\times74)+(0.91\times27)+(0.65\times81)]=151$ for the expected number of days of aurora in 182 days at Fort Rae. The observed frequency at Ssagastyr was 149 whence we estimate the percentage-frequency at Ssagastyr in the absence of cloud to be about $[(149/151)\times100]=99$, whence we also surmise Ssagastyr to be on the zone of maximum auroral

frequency (essentially the same result is indicated in Tables 2 and 3, reduced using cloud-amounts observed at Ssagastyr).

In further illustration of this procedure consider the means of six years of observation for a five-month period at Calm Bay. The average numbers of days per five-month period were 30, 15, and 104 with average amounts of cloud 0 to 2.5, 2.6 to 7.5, and 7.6 to 10, respectively. Using the Fort Rae results as before, if the aurora appeared every night at Calm Bay there would be expected $[(0.98\times 40)+(0.91\times 20)+(0.65\times 122)]=136$ observations of aurora per average six-month period. The number actually seen was 97, whence the estimated percentage-frequency becomes $[(97/136)\times 100]=71$. But Fort Rae is an inland station and Calm Bay on an island, so that this result is likely to be bad.

At Angmagsalik, to illustrate a case taken at random for the 200-day period October 1, 1884, to April 18, 1885 (meaning 10 readings of cloudiness daily), there was obtained the corresponding sum $[(0.98\times 60)+(0.91\times 48)+(0.65\times 92)]=163$ expected observations with 90 actually observed yielding a percentage-frequency of 55. The observer states 49 nights were too cloudy for auroral observation so that there were 90 seen on a possible 161 nights, yielding a percentage-frequency of 56, and hence in good agreement with results based on the effect of clouds on observation of aurora at Fort Rae. Although methods of this kind are somewhat rough, and their cautious use implies some knowledge of meteorological conditions, they seem to afford a useful means of roughly estimating the frequency of aurora in the absence of clouds.

We next consider the correction of observed frequencies of aurora for daylight-conditions affecting the number of days of year yielding observations of aurora.

4—*Correction of observed data on auroral frequency for seasonal inequalities in duration of night*

Figure 5 shows the variation with geographic latitude in the period of continuous sunlight during northern summer. Curve (A) shows for various latitudes the date of year in spring or early summer on which the Sun is on the horizon at local midnight, and following which there will be continuous daylight 24 hours of the day, and the corresponding date at which the Sun again returns to horizon-level.

For about a month before and following the continuous daylight period the sky is too brightly illuminated to be favorable for the observation of aurora. The number of days on which aurora are observed is also reduced because the number of night hours available for observing aurora becomes fewer, as the period of continuous sunlight is approached.

Also shown in the figure are the dates of the last and first observations of aurora prior to and following the continuous daylight period at stations in various latitudes observing throughout various years 1871-1942. These dates are of course affected also by other factors such as the amount of cloudiness influencing observation, and the probability of the occurrence of aurora, which, except near the auroral zone, is such that aurora may not be expected every clear night. However, the dates on the whole seem distributed with considerable symmetry relative to the curve (A). A curve (B) has accordingly been drawn among the

points representing dates and affords a rough average determination of the date of disappearance and reappearance of aurora preceding and following the period of continuous daylight in various northern latitudes; the same curve (B) should also apply in the southern hemisphere if shifted in phase by six months in time.

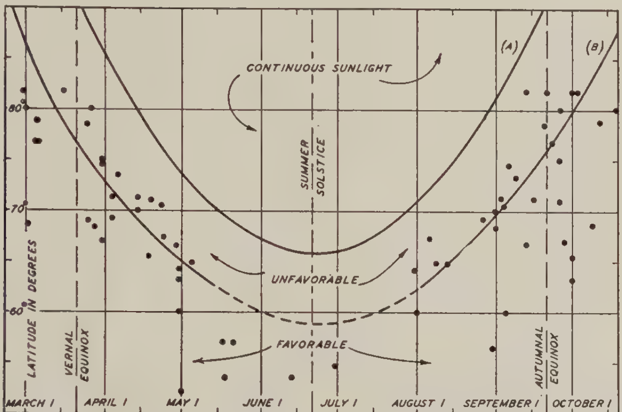

FIG. 5—(A) SUN ON NORTHERN HORIZON AT LOCAL MIDNIGHT, LATITUDES 50° TO 90° NORTH; LIMITING DATES (•) OF VISUAL AURORAL OBSERVATIONS FOR VARIOUS STATIONS 50° TO 90° NORTH; AND (B) AVERAGE SMOOTHED GRAPH OF LIMITING DATES.

In the present study, curve (B) serves the useful purpose of defining and estimating the number of days per year too sunlit for the favorable observation of aurora. The curve also permits the elimination of auroral observations made under poor seeing conditions so that samples from series of auroral observations at various stations can be reduced to a more uniform and intercomparable basis, more nearly independent of the effect of sunlight. During these days of long twilight there might be observed and recorded only the brightest of aurora, weak aurora of type found to occur at other times of year being absent in the record.

5—*Tables of auroral frequencies*

Table 1 lists auroral frequencies for stations arranged according to geographic latitude, for the First International Polar Year, September 1, 1882, to August 31, 1883. There appears first the station, position, period of observation, and the number of days with visual observations of aurora. The number of nights too cloudy for visual observation of aurora is given, when noted by the observer, or when estimated using procedures indicated in the supplementary notes. There is next listed the number of days within the observation period and the number of nights too sunlit for observation of aurora. The percentage frequencies given in Tables 1, 2, and 3 are based on an average of about one-third of all days of year assumed unsuited for auroral observation at the zone of maximum auroral frequency, that is, the estimated number of days of aurora per year under good conditions of observation at all times.

It will be noted that the periods of observation are of somewhat unequal length, chiefly because of the variation with latitude in the length of the continuous daylight-period in high latitudes. However, since the seasonal variation in daily frequency is practically zero at the auroral zone, the unequal distribution of the lengths and times of observation-periods will be more important at stations more distant from this zone; thus there arises the possibility of weighting the winter observations as two with those for equinox one. However, this has not been done since the values for equinox are themselves incomplete. Further, the values for the winter season are in fact artificially given extra weight since there are then more observing hours per night thereby enhancing the probability of occurrence of aurora; these hours are arranged nearly symmetrically about the winter solstice. The correction for influence of the

TABLE 1—*Auroral stations and particulars, First International Polar Year*, 1882-83

Station	Geographic North latitude, ϕ	Geographic East longitude, λ	Geomagnetic North latitude, Φ	Geomagnetic East longitude, Λ	Available period observation From	Available period observation To
	°	°	°	°	*1882*	*1883*
Fort Conger	81.7	295.2	86.7	169.3	Oct. 1	Feb. 28
Cape Thordsen	78.5	15.7	74.5	131.7	Sep. 20	Mar. 25
Ssagastyr	73.4	126.6	62.2	189.5	Sep. 9	Apr. 1
Point Barrow	71.3	203.3	68.6	241.2	Sep. 3	Apr. 14
Jan Mayen	71.0	351.5	73.4	96.3	Sep. 5	Apr. 19
Bossekop	70.0	23.2	66.6	120.4	Sep. 1	Apr. 14
Koutokaeino	69.0	23.2	65.8	119.1	(x)	(x)
Sodankylä	67.4	26.6	63.8	120.0	Sep. 1	Aug. 31
Kingua Fjord	66.6	292.7	78.1	3.2	Sep. 13	Apr. 29
Godthaab	64.2	308.3	74.8	29.6	Sep. 1	Aug. 30
Fort Rae	62.6	244.3	68.9	291.4	Sep. 1	Aug. 31
Upsala	59.9	17.6	58.6	106.0	Sep. 1	Apr. 30
Nain	56.5	298.3	67.9	10.8	Oct. 1	Aug. 31

Station	Number of days: Available obs'ns	Number of days: Cloudy	Number of days: Sunlit Yearly	Number of days: Sunlit Excluded	No. of obs'ns aurora	No. of obs'ns used	Percentage frequency
Fort Conger	151	5(*a*)	210	4	67	62	49
Cape Thordsen	187	(*b*)	199	21	128	120	88
Ssagastyr	205	(*p*)	167	7	160	158	100
Point Barrow	224	32(*a*)	153	12	169	155	95
Jan Mayen	228	76(*m*)	151	13	133	129	93
Bossekop	226	(*c*)	144	15	168	167	100
Koutokaeino	...	(*n*)	136	0	...	...	100
Sodankylä	365	87(*a*)	125	125	148	103	74
Kingua Fjord	229	51(*a*)	113	4	119	106	67
Godthaab	364	(*a**)	90	90	134	134	77
Fort Rae	365	(*a**)	74	74	257	257	100
Upsala	242	81(*m*)	45	0	41	41	26
Nain	335	119(*a*)	0	0	140	125	64

(x) Record states merely "From 1882 to 1884."

TABLE 2—*Auroral stations and particulars, Second International Polar Year, 1932-33*

Station	Geographic North latitude, ϕ	Geographic East longitude, λ	Geomagnetic North latitude, Φ	Geomagnetic East longitude, Λ	Available period observation From	Available period observation To
	°	°	°	°	*1932*	*1933*
Bear Island	74.5	19.2	71.1	124.5	Sep. 6	Mar. 31
Ssagastyr	73.4	126.6	62.2	189.5	Oct. 1	Mar. 31
Point Barrow	71.3	203.3	68.6	241.2	Sep. 16	Apr. 20
Scoresby Sund	70.5	338.0	75.8	81.8	Sep. 4	Apr. 23
Godhavn	69.2	306.5	79.8	32.5	Aug. 27	Apr. 4
Abisko	68.4	18.8	66.0	116.0	Sep. 1	Mar. 28
Coppermine	67.8	244.9	73.7	284.9	Sep. 1	Aug. 26
Angmagsalik	65.6	322.4	74.2	52.7	Aug. 31	Feb. 14
College-Fairbanks	64.9	212.2	64.5	255.4	Aug. 13	May 5
Nome	64.8	194.6	61.3	241.8	Sep. 6	Dec. 31
Chesterfield Inlet	63.3	269.3	73.5	324.0	Oct. 1	Apr. 30
Fort Rae	62.8	243.9	69.0	290.9	Sep. 1	Aug. 31
Cape Hope's Advance	61.1	290.4	72.6	359.1	Sep. 1	Aug. 31
Balta Sound	60.8	359.1	63.1	89.4	Sep. 1	Apr. 30
Lerwick	60.1	358.8	62.5	88.6	Sep. 1	Apr. 30
Deerness	59.0	357.3	61.8	86.1	Sep. 1	Apr. 30
Kirkwall	59.0	357.0	61.8	85.8	Sep. 1	Apr. 30
Pentland Skerries	58.7	357.1	61.6	85.6	Sep. 1	Apr. 30
Wick	58.5	356.9	61.4	85.3	Sep. 1	Apr. 30
Juneau	58.3	225.7	61.3	275.5	Sep. 1	Aug. 31
Stornoway	58.2	353.6	61.8	81.7	Sep. 1	Apr. 30
Duntulm	57.7	353.6	61.3	81.3	Sep. 1	Apr. 30
Gordon Castle	57.6	356.9	60.6	84.6	Sep. 1	Apr. 30
Aberdeen	57.2	357.9	60.0	85.3	Sep. 1	Apr. 30
Sitka	57.0	224.7	60.0	275.4	Nov. 6	May 17
Tiree	56.5	353.2	60.3	80.0	Sep. 1	Apr. 30
Eskdalemuir	55.3	356.8	58.5	82.9	Sep. 1	Apr. 30
Meanook	54.6	246.7	61.8	301.0	Jan. 1*	June 30
Saskatoon	52.1	253.3	60.5	310.6	Oct. 2	May 1
Havre	48.5	250.2	56.5	308.3	Sep. 1	Aug. 31
Spokane	47.6	242.6	54.4	285.4	Sep. 1	Aug. 31
Sault Ste. Marie	46.5	275.6	57.5	340.1	Sep. 1	Aug. 31
Houlton	46.1	292.1	57.6	1.4	Sep. 1	Aug. 31
Ellendale	46.0	261.4	55.6	301.3	Sep. 1	June 30
Sheridan	44.8	253.0	53.3	313.0	Sep. 1	Aug. 31
Burlington	44.5	286.8	55.9	354.7	Sep. 1	Aug. 31
Madison	43.1	270.6	53.7	334.5	Sep. 1	Aug. 31
Albany	42.7	286.3	54.1	354.1	Sep. 1	Aug. 31
Cleveland	41.5	278.3	52.6	344.3	Sep. 1	Aug. 31

*Of the year 1933.

number of observing hours per night would require also a knowledge of the daily variation of aurora, since the probability of occurrence of aurora depends on the hour of day. A derivation is being made of these daily variations at many stations, which might then permit some slight improvement in the estimated frequencies. These refinements for purposes of the present paper will be neglected.

The most noteworthy feature of Table 1 is the fact that aurora occur practically every day at Fort Rae, Cape Thordsen, Koutokaeino, and Ssagastyr, at the auroral zone. Near the center of the auroral zone, as shown by Fort Conger, the aurora appear with less than half the frequency observed at the auroral zone, for this year near sunspot-maximum.

Table 2—*Auroral stations and particulars, Second International Polar Year, 1932-33*—Concluded

Station	Number of days				No. of obs'ns aurora	No. of obs'ns used	Percentage frequency
	Available obs'ns	Cloudy	Sunlit				
			Yearly	Excluded			
Bear Island	207	108(*a*)	170	12	136	84	100
Ssagastyr	182	(*p*)	167	0	149	149	100
Point Barrow	217	76(*a*)	153	14	139	118	100
Scoresby Sund	232	(*d*)	148	15	184	184	99
Godhavn	221	(*e*)	136	3	134	134	98
Abisko	209	(*c*)	129	0	160	160	100
Coppermine	360	108(*a*)	125	125	165	134	100
Angmagsalik	168	(*d*)	111	0	133	133	100
College-Fairbanks	266	48(*n*)	104	6	191	191	88
Nome	117	(*f*)	102	0	35	35	47
Chesterfield Inlet	212	43(*n*)	78	0	159	159	94
Fort Rae	365	(*n*)	74	74	249	249	100
Cape Hope's Advance	365	201(*a*)	62	62	168	105	100
Balta Sound	242	(*g*)	57	0	11	11	5
Lerwick	242	93(*n*)	46	0	53	53	36
Deerness	242	(*g*)	18	0	7	7	4
Kirkwall	242	(*g*)	18	0	6	6	3
Pentland Skerries	242	(*g*)	...	...	7	7	4
Wick	242	(*g*)	...	...	13	13	7
Juneau	365	(*g*)	...	...	9	9	10
Stornoway	242	(*g*)	...	...	4	4	2
Duntulm	242	(*g*)	...	...	9	9	5
Gordon Castle	242	(*g*)	...	...	14	14	7
Aberdeen	242	(*g*)	...	...	7	7	4
Sitka	193	125(*n*)	...	...	10	10	15
Tiree	242	(*g*)	...	...	6	6	3
Eskdalemuir	242	(*g*)	...	...	4	4	2
Meanook	181	31(*n*)	...	...	71	71	37
Saskatoon	212	101(*n*)	...	...	39	39	35
Havre	365	122(*m*)	...	...	37	37	15
Spokane	365	122(*m*)	...	...	5	5	2
Sault Ste. Marie	365	122(*m*)	...	...	26	26	11
Houlton	365	134(*n*)	...	...	55	55	24
Ellendale	303	101(*m*)	...	...	8	8	4
Sheridan	365	122(*m*)	...	...	4	4	2
Burlington	365	(*a*)	...	...	8	8	3
Madison	365	122(*m*)	...	...	17	17	7
Albany	365	(*a*)	...	...	19	19	6
Cleveland	365	122(*m*)	...	...	4	4	2

Table 2 lists in a manner similar to that in Table 1 the frequencies of aurora observed during the Second International Polar Year for the period September 1, 1932, to August 31, 1933, which in contrast to the Polar Year, 1882-83 occurs near sunspot-minimum. The general indications are in good agreement with those of Table 1. As noted previously, the stations in lower latitudes serve usefully in permitting a reduction of data to the epoch of the data of Fritz.

Table 3 includes data for various years other than the First and Second International Polar Years, for the period 1871 to 1942.

TABLE 3—*Auroral stations and particulars, various years, 1871-1942*

Station	Geographic North latitude, ø	Geographic East longitude, λ	Geomagnetic North latitude, Φ	Geomagnetic East longitude, Λ	Available period observation From	Available period observation To
	°	°	°	°		
Floeberg Beach	82.5	298.5	85.8	164.6	Oct. 25, 1875	Dec. 17, 1875
Polar Star	81.8	58.0	72.3	157.9	Sep. 13, 1899	Jan. 30, 1900
Rudolph Island	81.8	58.0	72.3	157.9	Oct. 3, 1903	Mar. 16, 1904
					Oct. 19, 1904	Feb. 21, 1905
Fort Conger	81.7	295.2	86.7	169.3	Sep. 21, 1881	Feb. 28, 1882
Calm Bay	80.3	52.8	71.5	153.3	Oct.-Feb.,	1929-34
Treurenberg	80.0	17.0	75.3	136.6	Sep. 26, 1899	Mar. 27, 1900
Northbrook Island	80.0	50.0	71.5	151.3	Oct. 18, 1904	Mar. 1, 1905
Sergei Kamenev Is.	79.5	91.2	68.3	170.4	Oct.-Feb.,	1930-34
Rice Strait	78.8	285.1	88.8	255.1	Sep. 19, 1898	July 24, 1899
Refuge Harbor	78.5	287.6	89.3	266.4	Sep. 1, 1923	June 30, 1924
Cape Desire	77.0	68.6	67.2	157.0	Oct.-Feb.,	1931-34
Gaasefjord I	76.8	271.3	85.5	282.2	Sep. 18, 1900	Aug. 12, 1901
Gaasefjord II	76.7	271.4	85.4	283.9	Sep. 6, 1901	July 21, 1902
Havnefjord	76.5	275.9	86.2	294.4	Oct. 23, 1899	Aug. 9, 1900
Russian Harbor	76.2	62.6	67.0	152.9	Oct.-Feb.,	1932-34
Maud, II	75.1	159.5	65.9	208.2	Sep. 26, 1923	Mar. 31, 1924
Maud, I	73.6	172.2	65.9	217.3	Sep. 26, 1922	Mar. 29, 1923
Ssagastyr	73.4	126.6	62.2	189.5	Sep. 8, 1883	Apr. 19, 1884
Matochkin Shar	73.3	56.4	64.8	146.5	Oct.-Mar.,	1929-33
Great Liakhovsky Is.	73.2	143.2	62.8	199.7	Oct.-Mar.,	1928-35
Malya Karmakuly	72.4	52.7	64.5	143.3	Oct.-Mar.,	1929-34
Tixi Bay	71.6	129.0	60.5	191.4	Oct.-Mar.,	1932-35
Point Barrow	71.3	203.3	68.6	241.2	Oct. 17, 1881	Apr. 20, 1882
Wrangel Island	71.0	181.5	64.8	226.1	Oct.-Mar.,	1926-?
Maud, III	70.7	162.4	62.1	213.1	Sep. 29, 1924	Apr. 6, 1925
Jacobshavn	69.2	309.0	79.5	37.2	Sep.-Mar.,	1873-80
King Point	69.1	221.9	70.2	259.5	Oct. 22, 1905	Mar. 26, 1906
Cape Otto Schmidt	68.9	180.5	62.8	227.5	Oct.-Mar.,	1932-?
Gjöahavn	68.6	264.1	77.8	309.0	Nov. 4, 1903	Mar. 12, 1904
					Oct. 9, 1904	Mar. 2, 1905
Kultala	68.5	26.8	64.7	121.3	Jan. 21, 1884	Mar. 2, 1884
Sodankylä	67.4	26.6	63.8	120.0	Sep. 1, 1883	Aug. 31, 1884
Vega	67.1	186.6	62.1	233.6	Sep. 28, 1878	July 18, 1879
Ouellen	66.2	190.2	61.8	237.0	Oct.-Mar.,	1928-?
Angmagsalik	65.6	322.4	74.2	52.7	Oct. 1, 1884	Apr. 18, 1885
Sukkertoppen	65.1	307.3	75.8	28.7	Sep.-Mar.,	1875-79
College-Fairbanks	64.9	212.2	64.5	255.4	Aug. 9, 1930	May 7, 1931
					Aug. 13, 1931	May 5, 1932
					Aug. 15, 1933	Apr. 20, 1934
Bowdoin Harbor	64.4	282.1	75.5	344.4	July 1, 1921	Sep. 30, 1922
Godthaab	64.2	308.3	74.8	29.6	Sep.-Mar.,	1871-80
Ivigtut	61.2	312.0	71.5	33.0	Sep.-Mar.,	1875-80
Haroldswick	60.8	359.2	63.1	89.5	Jan. 1, 1928	Apr. 30, 1928
					Sep. 1, 1928	Dec. 31, 1928
Nennortalik	60.1	315.0	70.1	36.5	Nov.-Apr.,	1883-84
					Nov.-Apr.,	1884-85
Lerwick	60.1	358.8	62.5	88.6	Sep.-Apr.,	1924-29
Oslo	59.9	10.7	60.0	99.1	Jan. 1, 1938	Dec. 31, 1938
Sitka	57.0	224.7	60.0	275.4	Seasons of 1924-26 and 1927-33	
Edmonton	53.6	246.5	60.8	301.5	June 13, 1941	May 18, 1942
					Sep. 1, 1942	Oct. 31, 1942
Toronto	43.7	280.5	54.9	346.7	1915-30	
					1870-80	
Contoocooksville	43.0	288.1	54.5	356.4	1871-79	
Ithaca	42.5	283.5	60.8	359.2	Jan. 1, 1938	Apr. 23, 1939
Yerkes	42.5	271.5	53.2	335.8	1897-1909	
Blue Hill	42.2	288.9	53.7	357.2	1886-1940	
New York Harbor	40.8	286.2	52.2	354.1	Feb. 1, 1870	Dec. 31, 1880

TABLE 3—*Auroral stations and particulars, various years, 1871-1942*—Concluded

Station	Number of days				No. of obs'ns aurora	No. of obs'ns used	Percentage frequency
	Available obs'ns	Cloudy	Sunlit				
			Yearly	Excluded			
Floeberg Beach	54	(*h*)	216	0	4	4	7
Polar Star	140	60(*a*)	210	22	53	46	87
Rudolph Island	146	77(*a*)	210	5	58	53	91
Fort Conger	181	15(*a*)	210	34	37	36	30
Calm Bay	151	(*p*)	206	...	87	87	95
Treurenberg	183	(*q*)	206	24	121	114	82
Northbrook Island	135	62(*n*)	206	...	53	51	70
Sergei Kamenev Is.	151	(*i*)	205	...	86	86	95
Rice Strait	309	6(*a*)	200	144	16	16	11
Refuge Harbor	304	60(*a*)	199	137	4	4	4
Cape Desire	151	(*p*)	188	...	64	64	67
Gaasefjord I	329	17(*a*)	188	152	3	3	2
Gaasefjord II	319	2(*a*)	188	142	4	4	2
Havnefjord	291	8(*a*)	186	142	2	2	2
Russian Harbor	151	(*j*)	182	...	71	71	75
Maud, II	188	22(*a*)	178	7	142	130	90
Maud, I	185	28(*a*)	167	...	127	123	86
Ssagastyr	225	(*k*)	167	25	160	160	100
Matochkin Shar	182	(*p*)	166	...	93	93	83
Great Liakhovsky Is.	182	(*p*)	166	1	120	120	100
Malya Karmakuly	182	(*p*)	161	1	64	64	58
Tixi Bay	182	(*p*)	155	...	84	84	71
Point Barrow	186	29(*a*)	153	14	145	127	98
Wrangel Island	182	(*p*)	151	...	81	81	60
Maud, III	190	32(*a*)	148	...	95	87	60
Jacobshavn	212	(*e*)	137	...	22	22	17
King Point	156	75	136	...	54	45	56
Cape Otto Schmidt	182	(*p*)	134	...	67	67	58
Gjöahavn	137	26(*n*)	132	...	35	32	29
Kultala	42	32(*n*)	130	...	14	8	80
Sodankylä	366	(*c*)	125	125	107	107	59
Vega	294	(*f*)	119	88	66	66	49
Ouellen	182	(*p*)	114	...	40	40	34
Angmagsalik	200	(*q*)	108	...	90	90	55
Sukkertoppen	212	(*e*)	104	...	86	86	65
College-Fairbanks	263	126(*n*)	104	9	168	168	100
Bowdoin Harbor	457	252(*c*)	134	...	59	59	92
Godthaab	212	(*c*)	92	...	77	77	59
Ivigtut	212	(*e*)	34	...	142	142	93
Haroldswick	242	(*g*)	62	...	63	63	33
Nennortalik	181	(*e*)	46	...	104	104	93
Lerwick	242	93(*n*)	46	...	73	73	49
Oslo	365	122(*m*)	44	44	69	69	35
Sitka	236	138(*n*)	...	...	15	15	15
Edmonton	401	235(*n*)	...	...	82	82	49
Toronto	365	100(*n*)	...	...	5	5	2
	365	100(*n*)	...	...	5	5	2
Contoocooksville	365	122(*m*)	...	...	15	15	6
Ithaca	478	(*q*)	...	...	70	70	18
Yerkes	365	122(*m*)	...	...	13	13	5
Blue Hill	365	122(*m*)	...	...	5	5	2
New York Harbor	365	(*q*)	...	...	27	27	9

Table 4 indicates the abbreviations used to designate the various stations on Figures 6 and 7.

Unfortunately it is not possible to adopt a uniform procedure for the correction of observed auroral frequencies for the influence of cloudiness at all stations. In some cases adequate data for effecting corrections are available at the station. In others it appears likely that cloud-data for neighboring stations may be adequate to correct frequency at an auroral station lacking detailed and suitable particulars respecting cloudiness.

In Tables 1 to 3 the rough removal of the effect of clouds on the observed auroral frequency is accomplished by excluding from the observing period the nights on which the minimum hourly cloud-amount is seven or more. There will remain, however, the influence of cloudiness on the observations made on all other nights and the percentage-frequency estimated for such nights will probably be too small.

A study based on Figure 4 (B) shows that for the average of the stations Fort Rae, Godthaab, and Sodankylä, the correction for the average influence of the remaining amounts of cloud may be approximately obtained by multiplying the observed percentage-frequency by 1.1. For instance, at Fort Rae during 1882 to 1883, 217 cases of aurora were observed on 239 days not excluded as having minimum hourly cloud-amounts of seven or more, that is, on 91 per cent of the nights of

TABLE 4—*List of abbreviations for auroral stations*

Ab.	Station	Ab.	Station	Ab.	Station
Ab	Abisko	GC	Gordon Castle	NYH	New York Harbor
Abe	Aberdeen	Gj	Gjöahavn	Os	Oslo
Al	Albany	GLI	Great Liakhovsky Is.	Ou	Ouellen
An	Angmagsalik	Go	Godhavn	PB	Point Barrow
BH	Blue Hill	Gt	Godthaab	PeS	Pentland Skerries
BI	Bear Island	Ha	Haroldswick	PS	*Polar Star*
Bo	Bossekop	Hav	Havre	ReH	Refuge Harbor
BS	Balta Sound	Ho	Houlton	RH	Russian Harbor
BoH	Bowdoin Harbor	Hvn	Havnefjord	RI	Rudolph Island
Bu	Burlington	It	Ithaca	RS	Rice Strait
CB	Calm Bay	Iv	Ivigtut	Sa	Saskatoon
CD	Cape Desire	Ja	Jacobshavn	Sag	Ssagastyr
CF	College-Fairbanks	JM	Jan Mayen	Sh	Sheridan
Ch	Chelyuskin	Ju	Juneau	Si	Sitka
CHA	Cape Hope's Advance	KF	Kingua Fjord	SKI	Sergei Kamenev Is.
CI	Chesterfield Inlet	Ki	Kirkwall	So	Sodankylä
Cl	Cleveland	Ko	Koutokaeino	Sp	Spokane
Co	Coppermine	KP	King Point	SS	Scoresby Sund
Con	Contoocooksville	Ku	Kultala	SSM	Sault Ste. Marie
COS	Cape Otto Schmidt	Le	Lerwick	St	Stornoway
CT	Cape Thordsen	Mad	Madison	Su	Sukkertoppen
De	Deerness	Ma I	*Maud* I	TB	Tixi Bay
Du	Duntulm	Ma II	*Maud* II	Ti	Tiree
Ed	Edmonton	Ma III	*Maud* III	To	Toronto
El	Ellendale	Me	Meanook	Tr	Treurenberg
Es	Eskdalemuir	MK	Malya Karmakuly	Up	Upsala
FB	Floeberg Beach	MS	Matochkin Shar	Ve	*Vega*
FC	Fort Conger	Na	Nain	Wi	Wick
FR	Fort Rae	Ne	Nennortalik	WI	Wrangel Island
Ga I	Gaasefjord I	NI	Northbrook Island	Ye	Yerkes
Ga II	Gaasefjord II	No	Nome		

3

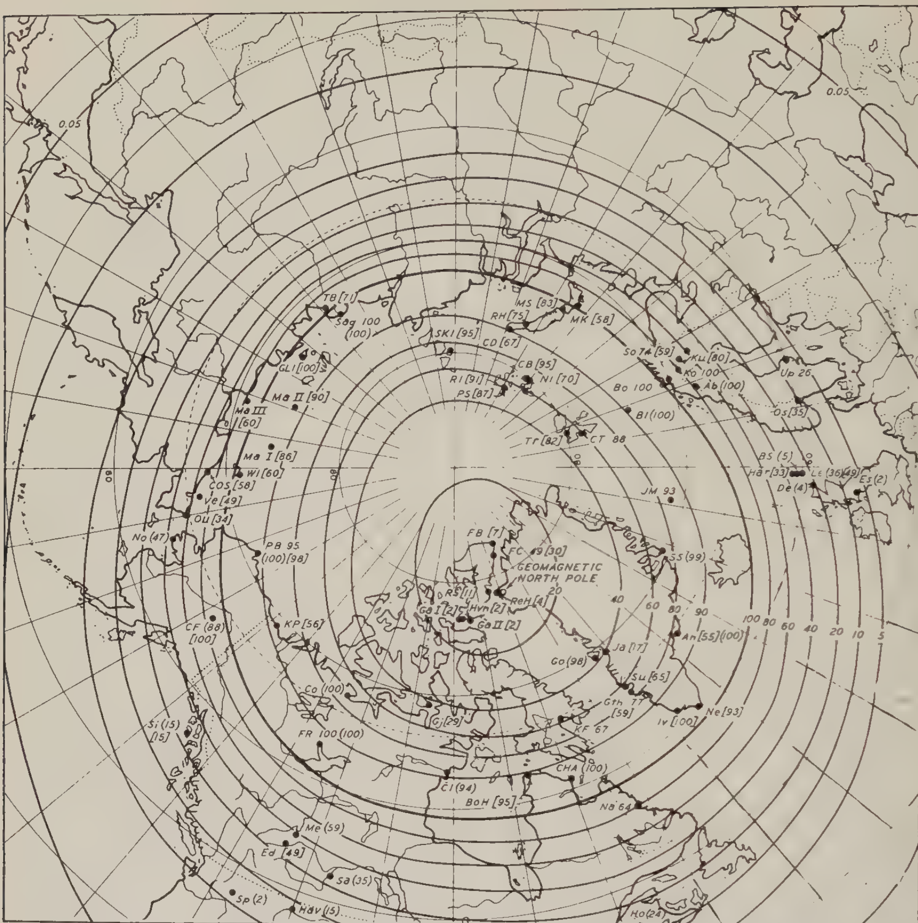

FIG. 6—ESTIMATED PERCENTAGE-FREQUENCY OF DAYS WITH OCCURRENCE OF AURORA, CLEAR, DARK, NIGHTS, HIGH LATITUDES, NORTHERN HEMISPHERE (STATIONS SHOWN BY LETTERS AS INDICATED IN TEXT)

LEGEND

RESULTS FROM	YEARS	PERCENTAGE-FREQUENCY MARKED THUS:
FIRST INTERNATIONAL POLAR YEAR	1882–'83	90
SECOND INTERNATIONAL POLAR YEAR	1932–33	(90)
OTHER OBSERVATIONS	FROM 1871–1942	[90]

observation. Since the true frequency appears to be 100 per cent for reasons mentioned previously, the correction-factor is taken to be 1.1, verified to be the same in the case of the mean of the three stations. This procedure is designated (*a*) whenever used in obtaining the estimated percentage-frequencies of Tables 1 to 3. When followed by an asterisk, the frequency is derived from Figure 4 (A) for nights of hourly maximum cloud-amount six or less, which appears to afford one of the best possible procedures of correcting the percentage-frequencies for the influence of cloudiness; it is best applied, however, at stations with high frequency of auroral occurrence and for many years' data combined

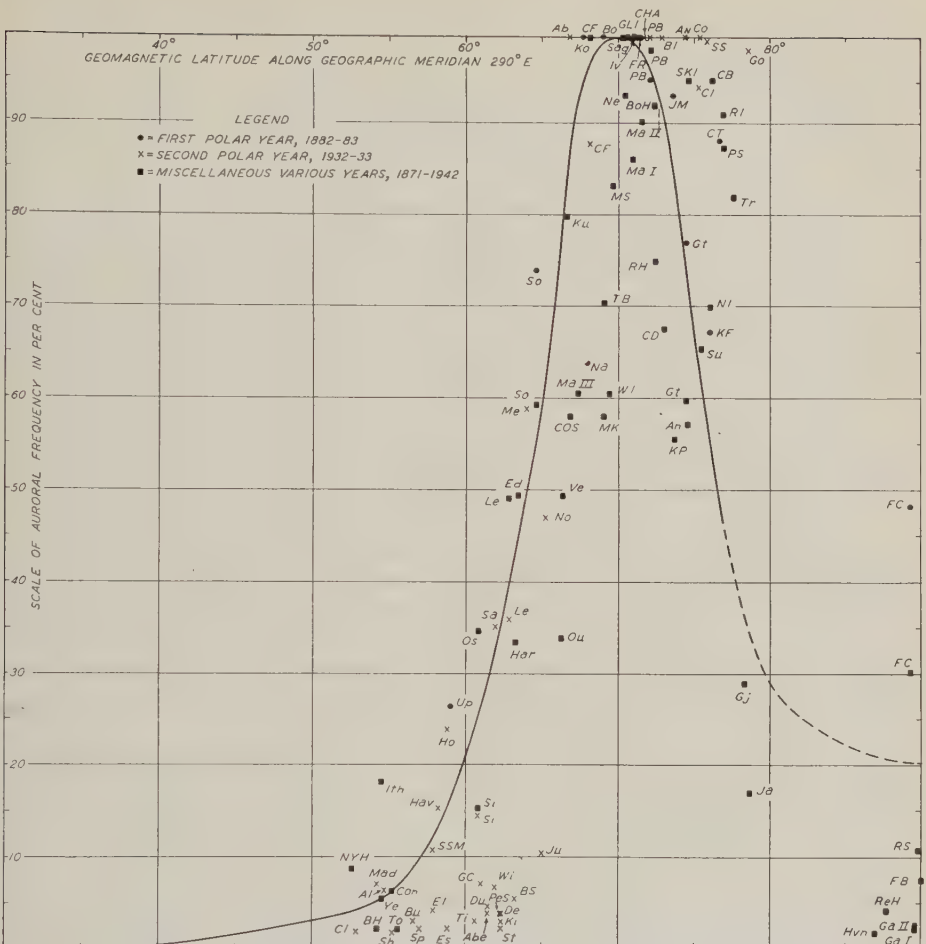

FIG. 7—ESTIMATED AVERAGE AURORAL PERCENTAGE-FREQUENCY ON CLEAR, DARK, NIGHTS, MERIDIAN 290° EAST, ADJUSTED TO CIRCULAR ZONE MAXIMUM AURORAL DISPLAY IN GEOMAGNETIC LATITUDE 69° NORTH

since at most stations there are few nights which fall into this classification.

In the case of observations during 1882 to 1883 at Cape Thordsen, hourly cloud-amounts were not available to the writer. Accordingly, the cloud-data obtained at the neighboring station of Treurenberg during 1899 to 1900 were used; the corrected frequency of the latter was 22 per cent greater than the frequency uncorrected for cloudiness, and this increase in frequency has accordingly been made for Cape Thordsen [procedure indicated by (*b*) in Tables]. A like procedure was used as indicated in the Tables for other stations, the years of cloud-data and increases in frequency in per cent and tabular indications being, respectively: (*c*) Sodankylä, 1882-83, 34 per cent; (*d*) Angmagsalik, 1884-85, 12 per cent; (*e*) Godthaab, 1882-83, 60 per cent; (*f*) Ouellen, from 1928, 55 per cent; (*g*) Aberdeen, 1932-33, 30 per cent; (*h*) Fort

Conger, 1882-83, 0 per cent; (*i*) Calm Bay, 1929-34, 65 per cent; (*j*) Cape Desire, 1931-34, 60 per cent; (*k*) Ssagastyr, 1932-33, 22 per cent; (*l*) Cape Hope's Advance, 1932-33, 82 per cent.

For a few stations, tabular designations (*m*), in lower latitudes (and for which the observed frequency was small) one-third of all observing nights were assumed cloudy whenever more satisfactory cloud-data were not available.

The tabular indication (*n*) is used when the observer has noted the number of nights on which aurora, if present, could not be seen on account of clouds. The percentage-frequencies are then estimated assuming aurora, if present, could be seen on all remaining dark nights of the observing period.

In a few cases indicated by (*o*) the only data found respecting observation of aurora at a station consisted of a statement that aurora were noted on a certain percentage of all clear nights; this percentage-frequency has accordingly been entered in the Tables.

Under (*p*) and subsequent designations the procedure used was based on the percentage of days of various average daily cloud-amounts, available for each month only of the observation-period—usually the means of several years. This procedure has already been illustrated for the stations Calm Bay and Ssagastyr. In all cases there is estimated the expected number of observations of aurora on days of average cloud-amounts 0 to 2.5, 2.6 to 7.5, and 7.6 to 10, if the aurora were incident with frequency of 100 per cent. The estimated percentage-frequency was accordingly derived from the ratio of the number of aurora actually observed to the expected number for the entire period of observation.

In using the foregoing procedure the designations, stations, and expected percentages of days with observations of aurora on days of average cloud-amount 0 to 2.5, 2.6 to 7.5, and 7.6 to 10, respectively, are as follows: (*p*) based on neighboring stations afforded by average for auroral observations on the *Maud*, 1922-23, 1923-24, and 1924-25, 99, 88, and 47 per cent of days, respectively; (*q*) based on Fort Rae, 1882-83, 98, 91, and 65 per cent, respectively.

The foregoing corrections for clouds leave much to be desired from the standpoint of precision. They afford at best only rough and tentative corrections and there are numerous weaknesses in the procedures adopted. Exhaustive study of the cloud-data in high latitudes would probably yield some significant improvement in the results, but the present published data on cloud-amount should be supplemented by use of actual observations of cloud-amount in order that the data be available in the best possible form. Such a study is beyond the scope of the present undertaking. It is felt, however, that the present corrections in auroral frequency for cloudiness, though defective in several important respects, do afford a good first approximation to the true percentage-frequencies.

With regard to future observations the present study suggests as highly desirable more careful attention to cloudiness prevailing during the period of auroral observation. Hourly estimates of cloud-amount, which would obscure aurora if present, should be available throughout the observing period of nights. It is particularly important that such estimates be available for nights on which aurora are not observed.

The procedure of noting the aurora on clear hours is adequate only when the observation-period extends over several years.

Of especial interest are the observations near the center of the auroral zone, for four different years from observations made during winter stays of the *Fram*, and the observations at Floeberg Beach, and Fort Conger. Most of the nights were clear during observations at these stations, so that there is clearly defined the marked decrease in frequency near the geomagnetic north pole. At Calm Bay, near the geographic north pole, the standard frequency is considerably higher (230 nights of aurora) as compared with the average of 10 nights of aurora for the mean of four years of observation on the *Fram* (Rice Strait, Gaasefjord I and II, and Havnefjord). These findings are further confirmed by the observations at Rudolf Island, Northbrook Island, noted on the "Ziegler" expedition, Treurenberg, Sergei Kamenev Islands, Cape Desire, and on the *Polar Star*.

Of particular interest are the possible variations in frequency with epoch, near the center of the auroral zone. There is here at least some evidence suggesting a marked variation with sunspot-cycle. At Fort Conger there were observed 37 aurora by Greely and others from September 21, 1881, to February 28, 1882, near but just before sunspot-maximum, whereas there were 67 aurora observed during the period October 1, 1882, to February 28, 1883, at about sunspot-maximum. As mentioned previously, these results are particularly significant since in this region there are few cloudy days affecting observation. In this same region the observations by Sverdrup and others of the *Fram* at Rice Strait, September 19, 1898, to July 24, 1899; Havnefjord, October 23, 1899, to August 9, 1900; Gaasefjord I, September 18, 1900, to August 12, 1901; and Gaasefjord II, September 6, 1901, to July 21, 1902, yielded 16, 2, 3, and 4 observations of aurora, respectively. These observations, unlike those at Fort Conger, were made near sunspot-minimum (about 1902). This suggests the possibility of a marked increase in auroral frequency in this region with increase in sunspot-number. This may be a consequence of increase in the general intensity of aurora near sunspot-maximum. Near the auroral zone the frequency is not much affected, however, but since the average position of this zone is somewhat further to the south at or just following a sunspot-maximum, stations just inside may actually experience a slight diminution in frequency near sunspot-maximum, as seems possible from examination of the data studied by Tromholt [15] for Ivigtut, based on the observations of Hoffmeyer.

A few stations for middle latitudes are included, which have frequencies subject to marked variations with sunspot-number. In the series of observations near New York Harbor, given by Greely, following the unusually marked sunspot-maximum of 1870, there were noted 60 aurora per year which declined to one or two per year in 1878.

6—*Isochasms based on standard frequencies, high latitudes*

Figure 6 illustrates the geographic variation in the standard frequencies of aurora estimated for the Polar Years, 1882-83, 1932-33, and for other years, based on the data of Tables 1, 2, and 3. The general

distribution is zonal, with a maximum-zone clearly indicated, and there is as well a notable diminution in frequency polewards. These data have also been plotted in Figure 7 along the meridian 290° east, assuming the frequency within the auroral zone to be distributed with zonal symmetry relative to this zone. This adjustment was effected noting the minimum distance in degrees of latitude to the auroral zone afforded from the geomagnetic data, and adjusting to a circular auroral zone in geomagnetic latitude 69° north. This simple basis for the plotting of the observed data along the meridian 290° east is of course rough, but seems to serve at least as a useful first approximation since the points appear to conform more or less closely to a smoothed curve tentatively drawn among the points.

It had been expected that there would emerge evidence of the need of correcting the observations of the Polar Year, 1882-83, for the difference in the level of auroral incidence from that for the Polar Year, 1932-33, but this does not appear to be possible with certainty on the basis of a single year of observations. The absence of large inconsistencies from this cause except near the center of the auroral zone seems to be due to the fact that the variation in the frequency of aurora in high latitudes does not depend much on sunspot-number. Thus, although the general level of intensity of aurora appears to vary with sunspot-cycle, the daily frequency of occurrence may be but slightly affected because the limits of variation in intensity as seen by eye are not sufficiently different in different years of the sunspot-cycle.

The data for 1882-83 and 1932-33 are for years near sunspot-maximum and sunspot-minimum, respectively, and their means thus form our basic information for the interzonal distribution of isochasms, and we regard the data for other years as subsidiary material affording a rough approximation to those appropriate to 1932-33.

The error with respect to epoch introduced because of the foregoing assumptions will be slight near the auroral zone. Reductions to epoch on the basis of a selected group of European stations as employed by Fritz would of course be unsatisfactory for this region, since aurora show considerable variation in frequency with sunspot-cycle in middle and lower latitudes.

This increase in lower latitudes following a sunspot-maximum is no doubt mainly due to expansion of the auroral zone southward at times of great magnetic storms which then appear more frequently.

Inside the auroral zone the dependence on sunspot-cycle would be expected to be more marked for stations such as Godthaab and Godhavn, Greenland, in the region of most rapid average decline in frequency polewards. The results of Arrhenius [1] and Paulsen [12] lend some support to the supposition of a decline in frequency at such stations following sunspot-maximum, as compared with the corresponding increase at stations outside the auroral zone. But their results appear to definitely indicate a considerably smaller variation in auroral frequency than that experienced in lower latitudes. However, it should be borne in mind that the foregoing considerations apply mainly to frequency of aurora rather than intensity; the latter problem will not be studied here although it is not without some importance in the consideration of the frequency of visually observed aurora, especially under the less favorable seeing conditions here in general mainly excluded.

7—Isochasms, northern hemisphere

Figure 8 shows the average isochasms of equal auroral frequency obtained using the data of Figures 6 and 7 for higher latitudes and the data of Fritz outside the auroral zone, if in high latitudes it be assumed that there are two-thirds of the days of the year suited to the visual observation of aurora.

In Figure 9 is attempted an approximate derivation of the isochasms in the absence of clouds and other factors affecting the visual observation of aurora, in terms of percentage-frequency. For this purpose the general distribution of Figure 8 has been preserved, with slight smoothing of contours.

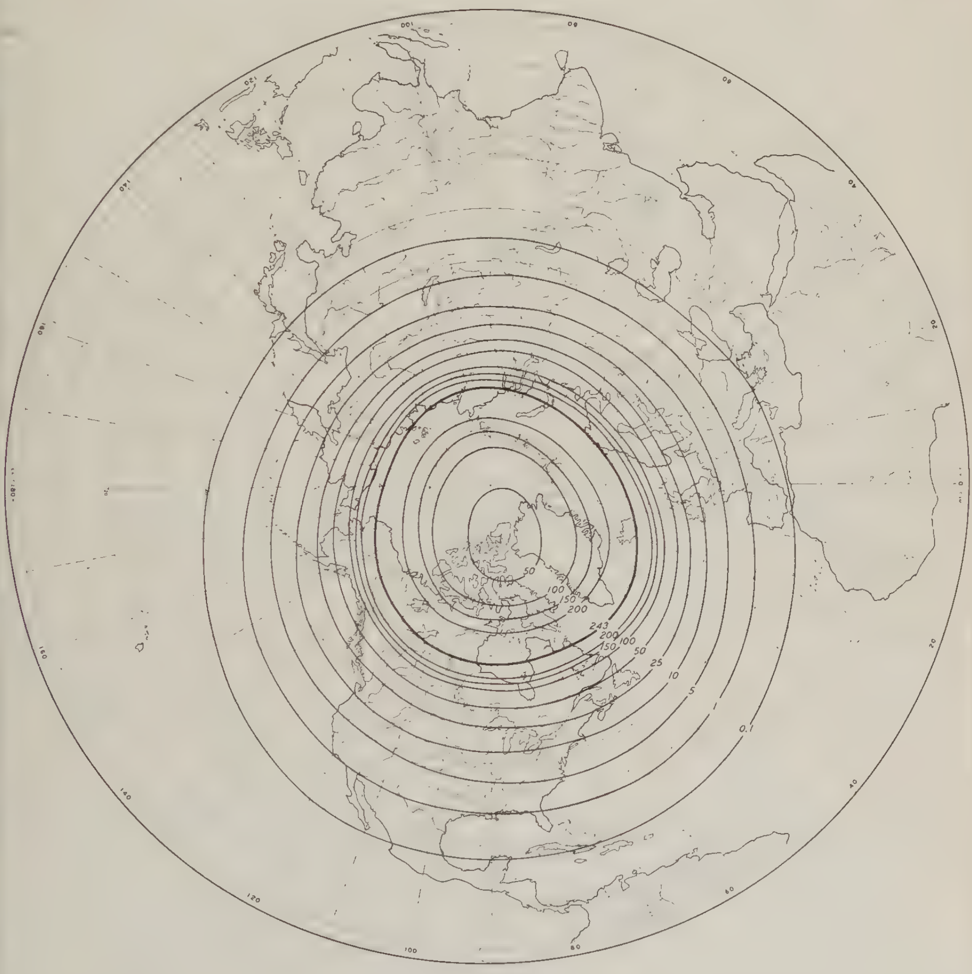

FIG. 8—ESTIMATED ANNUAL FREQUENCY OF DAYS OF VISIBLE AURORAL DISPLAY, NORTHERN HEMISPHERE (BASED ON FRITZ'S DATA, 1700-1872, AND LATER DATA, 1872-1942)

FIG. 9—ESTIMATED PERCENTAGE-FREQUENCY OF DAYS WITH OCCURRENCE OF AURORA, CLEAR NIGHTS, NORTHERN HEMISPHERE

8—*Isomagnetic lines of geomagnetic disturbance*

The isochasms of Figure 9 may be compared with curves of equal geomagnetic disturbance shown in Figure 10. The latter were obtained as the average maximum range in total force of the disturbance daily variation (S_D) for international disturbed days of the Polar Year, 1932-33 [18]. The directions of the disturbance-vectors at the time of morning minimum at each station were first used to adjust stations in geomagnetic latitudes 62° to 71° north to a circular auroral zone in latitude 67° north, thus obtaining the latitude-distribution of the disturbance daily variation (S_D) relative to this circular auroral zone. The

isomagnetic lines within this latitude-belt were next drawn symmetrically about the auroral-zone curve previously obtained from the magnetic data, and suitable proportionate adjustments made along the geomagnetic meridians.

It may be remarked that the latitude-distribution of the range in S_D is likely to afford a fair indication of the dependence on geographical position of the larger transient magnetic changes lasting from some minutes to several hours, such as appear in bays, especially in high latitudes. In lower latitudes the storm-time variation actually has for its daily mean for the same period a magnitude about equal to that of

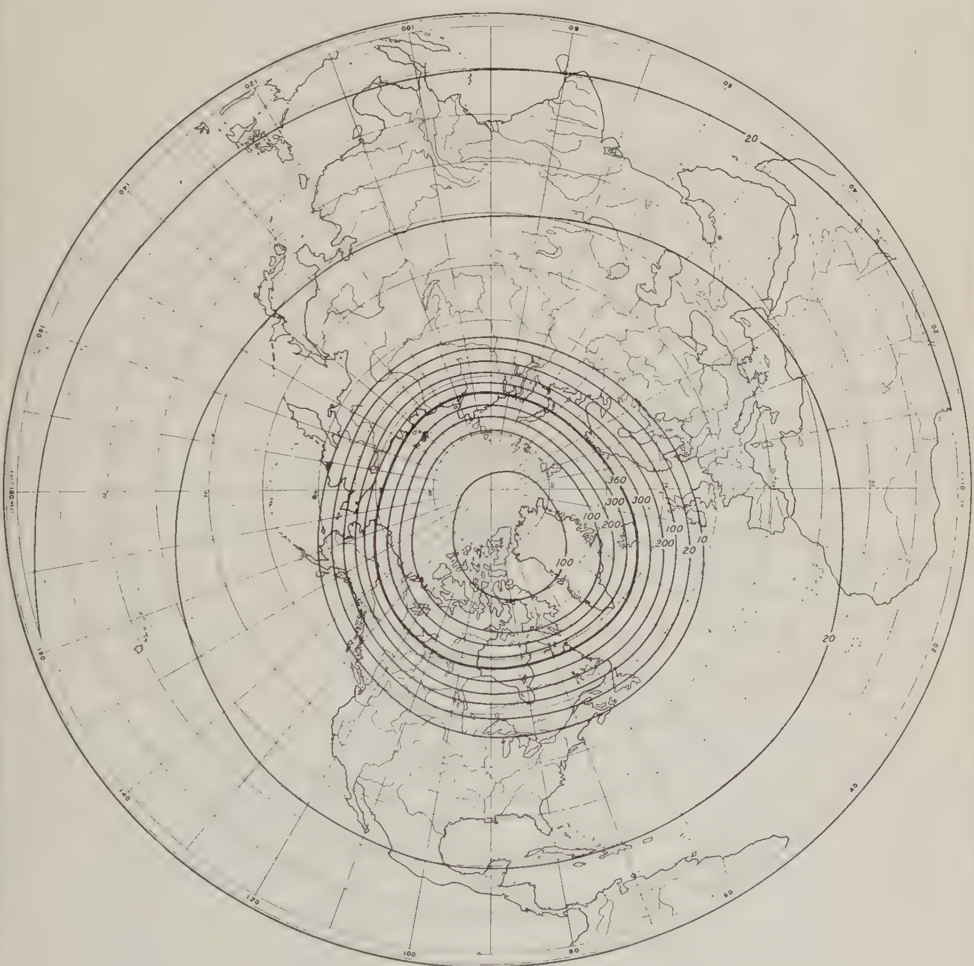

FIG. 10—LINES OF AVERAGE RANGE OF TOTAL-INTENSITY DISTURBANCE IN GAMMAS FOR 60 SELECTED INTERNATIONAL DISTURBED DAYS, SECOND INTERNATIONAL POLAR YEAR, 1932-33, NORTHERN HEMISPHERE

the average daily range in the total force-change in S_D. However, the field-changes of the storm-time variation are in general more gradual, except during the initial phases of magnetic storms, and hence less descriptive of the isomagnetics of disturbance appropriate to field-changes appearing for a few hours; the disturbance field of magnetic bays shows little evidence of the presence of a storm-time variation.

The line of average maximum total disturbance passes through northern Norway, skirts the south coast of Iceland, the southern tip of Greenland, and thence proceeds across Hudson's Bay to northern Alaska, and thence near the northern coast of Russia. About 7° of latitude inside the auroral zone there appears a subsidiary minimum in disturbance. There are also subsidiary maxima near geomagnetic north latitudes 20° and 90°.

The writer wishes to make grateful acknowledgment to his colleagues at the Department for constructive help, discussion, and advice.

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DEPARTMENT OF TERRESTRIAL MAGNETISM,
CARNEGIE INSTITUTION OF WASHINGTON,
Washington, D. C., March 13, 1944

AMERICAN MAGNETIC CHARACTER-FIGURE, C_A, THREE-HOUR-RANGE INDICES, K, AND MEAN K-INDICES, K_A, FOR JANUARY TO MARCH, 1944

By H. F. Johnston

Summaries of American *URSI* broadcasts have appeared regularly in this Journal since the issue for December, 1930.

As set forth in this Journal for June, 1937, "The Department of Terrestrial Magnetism and the United States Coast and Geodetic Survey with the cooperation of the United States Army and the United States

Table 1—*American magnetic character-figure C_A for Greenwich half- and full-days based on reports from Cheltenham, Honolulu, Huancayo, San Juan, Sitka, Tucson, and Watheroo for January to March, 1944*

Day	January			February			March[a]		
	0^h-12^h	12^h-24^h	0^h-24^h	0^h-12^h	12^h-24^h	0^h-24^h	0^h-12^h	12^h-24^h	0^h-24^h
1	0.3	0.9	0.6	0.0	0.0	0.0	0.2	0.3	0.2
2	0.0	0.1	0.1	0.2	0.0	0.1	0.3	0.2	0.2
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.1	0.1	0.0	0.4	0.2	1.0	0.6	0.8
5	0.7	0.3	0.5	0.0	0.1	0.0	0.0	0.6	0.3
6	0.0	0.2	0.1	0.0	0.0	0.0	0.9	0.8	0.9
7	0.0	0.0	0.0	0.8	1.4	1.1	0.9	0.9	0.9
8	0.1	0.1	0.1	0.9	0.9	0.9	0.6	0.8	0.7
9	0.1	0.1	0.1	0.6	0.7	0.6	0.9	0.9	0.9
10	0.1	0.7	0.4	0.9	0.6	0.8	1.0	0.9	0.9
11	0.9	1.0	1.0	0.9	0.5	0.7	0.6	0.4	0.5
12	0.9	0.8	0.8	0.5	0.6	0.5	0.7	0.8	0.8
13	0.9	1.0	1.0	0.2	0.6	0.4	0.8	0.5	0.6
14	0.7	0.9	0.8	1.5	0.6	1.1	0.8	0.2	0.5
15	0.6	1.0	0.8	0.4	0.8	0.6	0.0	0.0	0.0
16	0.8	0.7	0.8	0.4	0.0	0.2	0.2	0.1	0.2
17	0.8	0.7	0.8	0.0	0.0	0.0	0.0	0.0	0.0
18	0.5	0.6	0.5	0.0	0.0	0.0	0.0	0.8	0.4
19	0.2	0.4	0.3	0.0	0.0	0.0	1.0	0.7	0.8
20	0.4	0.5	0.4	0.4	0.9	0.6	0.3	0.0	0.2
21	0.0	0.1	0.0	0.6	0.1	0.3	0.0	0.2	0.1
22	0.0	0.1	0.0	0.0	0.0	0.0	0.7	0.5	0.6
23	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1
24	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0
25	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.6	0.3
26	0.0	0.8	0.4	0.0	0.0	0.0	1.3	1.0	1.2
27	0.3	0.4	0.3	0.0	0.0	0.0	1.5	0.5	1.0
28	0.4	0.1	0.2	0.0	0.0	0.0	0.2	0.5	0.3
29	0.0	0.1	0.1	0.4	0.4	0.4	1.0	0.3	0.7
30	0.0	0.0	0.0				0.5	0.5	0.5
31	0.0	0.4	0.2				0.6	0.0	0.3
Means..	0.3	0.4	0.3	0.3	0.3	0.3	0.5	0.4	0.5

[a]Honolulu not reporting March 12-31.

Table 2--Three-hour-range indices, K, January to March 1944

January 1944

	1	2	3	4	5	6	7	8
Si	3143 6632	2112 2221	0012 3001	1211 0221	3333 1322	0002 3212	1212 2111	1133 3210
Ch	3213 4323	2210 1121	1111 1000	1201 1212	4333 1222	0000 1112	2211 1111	1222 1111
Tu	2223 4223	2110 0210	0111 0000	1201 1111	4343 1211	0010 2101	1211 1110	0222 0210
SJ	3122 3233	1110 0111	1101 2000	1100 2122	3333 0421	0000 2211	2101 0000	1211 0100
Ho	1233 3322	2111 1111	0011 2001	1000 0112	2232 0201	0000 2101	1111 0011	0022 0101
Hu	2123 4542	1111 3331	1011 3111	1111 2331	2222 3321	0100 3322	1111 2321	1111 2311
Wa	1222 5443	2221 2422	1112 3111	1111 1122	3322 2432	1211 2212	1112 1211	1122 2321

	9	10	11	12	13	14	15	16
Si	1101 1311	2023 3334	2535 3552	2555 5622	4465 6333	3435 5652	3343 3543	3255 5532
Ch	2101 1103	1111 2136	3525 2452	2443 4333	5444 4334	4534 3443	5432 3344	5344 4323
Tu	2000 1201	0111 1126	2425 2542	2534 4412	5354 4233	3434 4553	3242 3344	4345 3422
SJ	1000 1112	0011 2226	3423 2542	3322 3333	4333 3133	3333 2543	3321 2333	3233 2323
Ho	1100 1222	1111 2125	3325 2321	2323 3312	4243 3233	2333 3333	3232 2333	3144 2212
Hu	1201 2311	1111 2245	2322 3542	2332 4332	3322 4442	2112 4432	3222 4543	3223 3432
Wa	3222 2312	2112 2233	3234 3552	2334 4432	3333 4332	2333 4532	2332 3344	2234 5322

	17	18	19	20	21	22	23	24
Si	3455 5433	1245 4432	2243 2322	1133 3323	2302 3311	2221 3211	1113 0012	2031 2310
Ch	3343 4333	1335 3432	3331 1323	2332 2223	2301 2111	3221 1211	2322 0013	2020 1310
Tu	3442 3321	1334 3221	3331 0212	1133 1224	1312 1121	2120 1010	1112 0003	2131 0300
SJ	3332 3332	0214 2332	3211 0322	1122 2213	1200 1011	2220 2300	1102 1013	2120 0310
Ho	3332 3122	1333 3311	1231 0212	1122 1212	0201 2111	1010 1100	0102 0002	1020 1211
Hu	2221 4432	0211 3442	2211 2421	1111 4432	1101 2220	1011 3331	1111 2222	2120 3331
Wa	3334 4422	2323 4332	2121 1323	2122 2333	2221 2221	1011 1121	1112 1112	1121 2321

	25	26	27	28	29	30	31	
Si	0112 3211	0003 2222	3244 3222	2133 1121	0113 2201	0111 2211	1111 1321	
Ch	0101 1212	0002 3323	3233 2222	3232 1221	2112 1211	2201 1001	1011 1222	
Tu	0111 1201	0012 3333*	3233* 2221*	3132 0110	1112 1101	0001 1000	1011 1110	
SJ	0111 2222	0001 2323	2211 1222	3221 0210	2110 2221	1100 1211	1000 1321	
Ho	1101 1101	0012 3412	1233 3121	2121 0111	0112 2001	1001 2011	0000 1110	
Hu	1112 2421	1011 4433	2212 3432	2221 2322	1000 2321	1001 2321	1000 3332	
Wa	1111 3221	1122 3443	2222 3232	2223 2221	1112 2111	1111 2111	1111 2232	

February 1944

	1	2	3	4	5	6	7	8
Si	2001 2210	0342 1211	1002 1100	0111 3321	0121 1121	1111 2110	1137 9644	3534 4334
Ch	2101 1010	0331 1011	1101 1000	2112 2221	0211 1122	1110 1110	1235 5445	5343 3344
Tu	1000 1110	1331 0011	1001 0000	0211 2311	1221 1111	1110 0010	2244 6435	4453 3335
SJ	1000 1110	0222 0101	0001 0000	0110 2311	0110 1010	0101 1000	1224 5343	4332 2244
Ho	1000 1001	0220 0010	1001 0000	0212 2211	0011 1010	0000 1011	1224 4333	3333 3223
Hu	1001 2321	0221 2321	1001 2111	1111 4541	0111 2221	2101 2221	2323 6653	3322 4543
Wa	2111 1121	1121 1111	1111 1011	1221 3331	1121 1332	1111 1212	2145 7534	3432 4433

	9	10	11	12	13	14	15	16
Si	1255 7422	2346 4332	3345 5322	3333 4321	1143 3214	5587 7322	3235 6333	2143 3211
Ch	1243 4322	3443 2332	5424 4223	4433 3332	1132 1225	5665 4332	4323 4333	3242 2212
Tu	1243 4331	2443 2322	3444 3212	4432 3321	1133 1215	5556 5311	3323 2332	2143 2211
SJ	1133 4221	2332 2321	3323 2212	2321 2121	1120 0114	5444 3221	3212 2323	2132 1101
Ho	1133 3211	1333 2122	2234 2211	2121 3111	1022 2113	4545 4221	2223 3221	1232 1101
Hu	1132 4442	2332 3432	3212 3332	2221 3331	1110 2333	4332 4431	2212 3332	2121 2321
Wa	1343 5332	2334 3332	3233 4432	2232 4332	1111 2324	6455 5331	3233 4443	1222 2311

	17	18	19	20	21	22	23	24
Si	1112 2211	0003 2000	0033 2100	0014 6522	2223 2221	1222 1110	0121 2110	0100 2110
Ch	2111 1111	0102 0000	1222 1010	0114 4434	4333 1212	3211 0011	2220 1001	0200 0011
Tu	1112 1101	0002 0100	1022 0000	0114 5323	3323 1202	2211 0111	1111 1001	0100 0001
SJ	1001 1001	0001 0000	1110 0100	0013 3223	3321 0112	2200 0010	1110 0001	0100 1010
Ho	1001 1100	0002 1000	0012 0000	0024 4312	1122 1112	0210 0010	1010 1000	0000 1000
Hu	1101 3310	0001 2220	1111 2320	0123 4532	2222 3322	2200 1220	1100 2210	1100 1110
Wa	1111 2211	1111 2111	1121 1100	1224 5333	2212 2223	2211 1111	1111 1211	1001 1111

	25	26	27	28	29			
Si	0121 0000	1113 0000	1011 2100	0022 3110	0222 2222			
Ch	1100 0001	0112 0001	1010 0000	1212 1011	1332 2222			
Tu	0110 0000	0112 0011	1011 1010	0112 2120	1332 1211			
SJ	0000 0100	0010 0011	1010 0010	0111 0120	1330 1222			
Ho	0000 0000	0001 0000	1000 1000	0011 1021	2121 2221			
Hu	1001 1211	0001 0111	1011 1120	1112 2320	2232 3331			
Wa	0011 1101	1112 2111	0101 1111	1111 2121	1232 3221			

* Interpolated.

Table 2--Three-hour-range indices, K, January to March 1944--concluded

March 1944

	1	2	3	4	5	6	7	8
Si	1231 0111	2312 3222	1031 0000	2256 6232	1023 2322	2435 4343	3464 6622	2434 5342
Ch	2230 0122	2311 2131	3221 0000	3255 4223	1113 1333	4434 3333	5543 4424	2432 3343
Tu	2230 0122	2321 2131	2131 0001	3355 5323	2122 1333	4434 2244	4544 4423	2433 4343
SJ	3220 0122	1301 2031	2211 0000	3334 3112	1002 1122	2323 2233	4422 3313	1322 2332
Ho	2130 0222	2211 1020	0011 0001	3234 4111	1011 0123	2224 2322	3333 3313	2322 3222
Hu	2121 2322	2212 2220	1120 2221	3234 4432	1110 2433	2322 3443	2322 4422	1322 3442
Wa	2111 1223	2222 3231	2112 1112	2344 4432	1112 3433	3334 4333	3234 5433	2333 4442
	9	10	11	12	13	14	15	16
Si	3536 5432	3567 6543	2445 2232	2334 4532	4434 5321	3454 3121	1210 2112	2424 3210
Ch	5434 4335	4554 4344	2434 2132	3433 4334	4432 3321	3433 2121	1321 1032	3412 2210
Tu	5535 4434	4554 5543	2435 2142	3434 3433	5433 3321	3434 2221	1321 1122	3322 2200
SJ	4413 3223	3343 3333	2223 1131	2323 2323	4322 2100	2322 0110	1210 0010	2201 1100
Ho	3324 3213	2344 4322	0323 1110	[a]---- ----	---- ----	---- ----	---- ----	---- ----
Hu	2323 4533	3323 4333	1222 2331	2321 4432	3211 3330	3322 3321	1212 2221	1211 3320
Wa	3334 4433	2345 5433	2124 2232	2233 4433	3223 4321	2233 3221	1121 1122	1212 3211
	17	18	19	20	21	22	23	24
Si	0001 1100	0021 1234	7425 4233	3144 3111	2210 1122	2334 4221	0233 2222	0002 2200
Ch	0100 0112	0031 2235	6423 3235	3132 1112	1300 0113	4432 3122	1232 1223	1101 1101
Tu	1011 1122	1131 2245	6424 2244	3033 1123	2311 2122	3334 4322	1333 2233	1012 1010
SJ	0000 0101	0021 1134	5312 2123	2120 0111	1300 0012	3422 3211	1221 0122	1000 0000
Ho	---- ----	---- ----	---- ----	---- ----	---- ----	---- ----	---- ----	---- ----
Hu	0000 1211	0121 3334	5322 4232	2112 2222	2200 2222	3311 3431	1121 2331	1001 2211
Wa	1011 0111	0131 2245	5324 4243	2123 2121	2111 1222	2223 4321	1221 1232	2111 1211
	25	26	27	28	29	30	31	
Si	0122 2232	3567 7224	6777 4322	0124 3323	3554 3321	3242 2223	2343 3000	
Ch	0212 2233	4554 5235	6655 3233	1213 1223	5444 1122	5231 1225	4333 1012	
Tu	0123 3243	4555 5335	6665 3322	1223 2223	4454 2222	4241 2225	3343 2012	
SJ	0112 2332	3543 5124	5633 2221	0102 0113	3343 1211	3220 1213	2322 1011	
Ho	---- ----	---- ----	---- ----	---- ----	---- ----	---- ----	---- ----	
Hu	0112 2342	3433 6334	4533 3332	1113 3323	3332 2322	3221 3323	2322 2121	
Wa	0113 2342	3456 5325	6655 4321	1123 2334	3433 3331	3232 3423	2222 3112	

[a]Honolulu not reporting March 12-31.

Navy communication-services and several amateur radio stations have undertaken to supply the American character-figure based upon the reports of the seven American-operated observatories—those of the Department of Terrestrial Magnetism at Huancayo in Peru and at Watheroo in Western Australia, and those of the United States Coast and Geodetic Survey at Cheltenham (Maryland), Honolulu (Hawaii), San Juan (Puerto Rico), Sitka (Alaska), and Tucson (Arizona)." The H-variometer at Honolulu was not in operation during the period from March 12 to March 31. This character-figure is being designated C_A, and its values for the first twelve, the second twelve, and all twenty-four hours of each Greenwich day for January to March 1944, are given in Table 1.

The three-hour-range indices, K, have been compiled since April 6, 1940, for each of the seven American-operated observatories. The eight indices for each day give geomagnetic activity for three-hour periods successively during the Greenwich day. The indices range from "zero" very quiet to "nine" extremely disturbed. The K-indices for Sitka (Si), Cheltenham (Ch), Tucson (Tu), San Juan (SJ), Honolulu (Ho), Huancayo (Hu), and Watheroo (Wa), for January to March 1944, are given in Table 2. Interpolated indices are shown thus, $\dot{3}$.

In the manner set forth in the JOURNAL for September, 1940, the indices are standardized into reduced indices K_r to eliminate local varia-

Table 3--Weighted average of reduced three-hour-range indices, January to March 1944

Day	January 1944									February 1944									March 1944[a)]								
	Values K_A								Sum	Values K_A								Sum	Values K_A								Sum
1	$2^\times$	2	$2^\times$	$2^\times$	4	$3^\times$	3	3	23	2	$0^\times$	0	$0^\times$	$1^\times$	1	1	$0^\times$	7	2	2	$2^\times$	$0^\times$	$0^\times$	$1^\times$	$1^\times$	2	$12^\times$
2	2	2	$1^\times$	$0^\times$	$1^\times$	2	2	$1^\times$	13	$0^\times$	$2^\times$	3	1	1	1	1	1	11	2	$2^\times$	$1^\times$	$1^\times$	$2^\times$	$1^\times$	$2^\times$	1	15
3	$0^\times$	$0^\times$	1	$1^\times$	2	0	0	1	$6^\times$	1	$0^\times$	0	1	1	$0^\times$	0	$0^\times$	$4^\times$	$1^\times$	1	2	$1^\times$	$0^\times$	$0^\times$	$0^\times$	$0^\times$	8
4	$1^\times$	$1^\times$	$0^\times$	1	1	$1^\times$	$1^\times$	2	$10^\times$	1	2	$1^\times$	1	2	3	2	1	$13^\times$	$2^\times$	$2^\times$	4	$4^\times$	4	$2^\times$	2	$2^\times$	$24^\times$
5	$3^\times$	3	3	$2^\times$	1	3	2	$1^\times$	$19^\times$	$0^\times$	$1^\times$	$1^\times$	1	1	$1^\times$	2	$1^\times$	$10^\times$	$1^\times$	$0^\times$	$1^\times$	2	$1^\times$	3	$2^\times$	3	$15^\times$
6	0	$0^\times$	$0^\times$	$0^\times$	2	2	1	2	$8^\times$	1	1	$0^\times$	$0^\times$	1	1	1	$0^\times$	$6^\times$	3	$3^\times$	3	4	3	3	$3^\times$	3	26
7	$1^\times$	$1^\times$	1	$1^\times$	1	$1^\times$	1	1	10	2	2	3	5	$6^\times$	4	$3^\times$	4	30	$3^\times$	$3^\times$	$3^\times$	3	4	4	2	3	$26^\times$
8	1	$1^\times$	2	2	1	2	1	$0^\times$	11	4	4	$3^\times$	$2^\times$	3	3	$3^\times$	4	$27^\times$	2	$3^\times$	3	$2^\times$	$3^\times$	$3^\times$	4	$2^\times$	$24^\times$
9	2	$1^\times$	$0^\times$	1	$1^\times$	2	1	2	$11^\times$	$1^\times$	2	4	3	$4^\times$	3	$2^\times$	2	$22^\times$	$3^\times$	4	$2^\times$	4	$3^\times$	$3^\times$	$2^\times$	$3^\times$	27
10	$1^\times$	1	$1^\times$	$1^\times$	2	2	3	5	$17^\times$	$2^\times$	$3^\times$	$3^\times$	$3^\times$	$2^\times$	$2^\times$	$2^\times$	2	$22^\times$	3	4	4	$4^\times$	4	4	$3^\times$	$3^\times$	$30^\times$
11	3	4	$2^\times$	$4^\times$	2	4	$4^\times$	2	$26^\times$	4	3	3	$3^\times$	3	$2^\times$	2	2	23	$1^\times$	3	$2^\times$	4	2	$1^\times$	$2^\times$	$1^\times$	$18^\times$
12	$2^\times$	4	$3^\times$	$3^\times$	$3^\times$	$3^\times$	$2^\times$	$2^\times$	$25^\times$	$3^\times$	3	3	2	3	$2^\times$	$2^\times$	$1^\times$	21	$2^\times$	3	3	3	$3^\times$	4	$2^\times$	3	$24^\times$
13	$4^\times$	$3^\times$	4	$3^\times$	4	$2^\times$	3	3	28	$1^\times$	1	$2^\times$	$1^\times$	$1^\times$	2	$1^\times$	$4^\times$	16	4	3	$2^\times$	$2^\times$	$3^\times$	3	$1^\times$	1	21
14	$3^\times$	4	3	$3^\times$	$3^\times$	$4^\times$	4	$2^\times$	$28^\times$	$5^\times$	5	$5^\times$	5	$4^\times$	$2^\times$	$2^\times$	$1^\times$	32	$2^\times$	3	3	3	$2^\times$	$1^\times$	$1^\times$	1	18
15	$3^\times$	3	3	2	$2^\times$	$3^\times$	4	$3^\times$	25	$3^\times$	$2^\times$	2	3	$3^\times$	3	3	3	$23^\times$	1	2	$1^\times$	1	1	$0^\times$	$1^\times$	$1^\times$	10
16	4	$2^\times$	$3^\times$	4	$3^\times$	3	2	$2^\times$	25	$2^\times$	2	$3^\times$	2	2	2	1	$1^\times$	$16^\times$	2	3	$1^\times$	2	$2^\times$	2	$0^\times$	0	$13^\times$
17	$3^\times$	$3^\times$	$3^\times$	3	$3^\times$	3	$2^\times$	$2^\times$	25	$1^\times$	1	$0^\times$	1	$1^\times$	$1^\times$	$0^\times$	1	$8^\times$	$0^\times$	0	$0^\times$	$0^\times$	$0^\times$	1	$0^\times$	1	$4^\times$
18	$1^\times$	3	$2^\times$	$3^\times$	3	3	$2^\times$	2	21	0	$0^\times$	0	$1^\times$	1	$0^\times$	$0^\times$	0	4	0	$0^\times$	$2^\times$	1	2	2	3	$4^\times$	$15^\times$
19	3	$2^\times$	$2^\times$	1	1	$2^\times$	2	$2^\times$	17	1	1	2	$1^\times$	1	1	$0^\times$	0	8	6	$3^\times$	2	$3^\times$	3	2	3	$3^\times$	$26^\times$
20	2	$1^\times$	$2^\times$	2	2	$2^\times$	2	3	$17^\times$	0	1	$1^\times$	4	$4^\times$	$3^\times$	$2^\times$	3	20	$2^\times$	1	$2^\times$	$2^\times$	$1^\times$	1	1	$1^\times$	$13^\times$
21	2	$2^\times$	$0^\times$	1	$1^\times$	$1^\times$	$1^\times$	1	$11^\times$	3	$2^\times$	2	$2^\times$	$1^\times$	2	$1^\times$	$2^\times$	$17^\times$	2	$2^\times$	$0^\times$	$0^\times$	1	$1^\times$	$1^\times$	2	$11^\times$
22	2	$1^\times$	$1^\times$	$0^\times$	$1^\times$	2	1	1	11	2	$2^\times$	1	1	$0^\times$	$0^\times$	1	$0^\times$	9	3	3	$2^\times$	$2^\times$	$3^\times$	$2^\times$	2	$1^\times$	$20^\times$
23	$1^\times$	$1^\times$	1	2	$0^\times$	$0^\times$	1	$2^\times$	$10^\times$	1	$1^\times$	$1^\times$	$0^\times$	1	1	$0^\times$	$0^\times$	$7^\times$	1	2	$2^\times$	$1^\times$	$1^\times$	2	2	2	$14^\times$
24	2	$0^\times$	$2^\times$	$0^\times$	$1^\times$	$2^\times$	$1^\times$	$0^\times$	$11^\times$	$0^\times$	1	0	0	1	0	$0^\times$	$0^\times$	$3^\times$	1	$0^\times$	$0^\times$	$1^\times$	1	$1^\times$	$0^\times$	$0^\times$	7
25	$0^\times$	$1^\times$	1	$1^\times$	2	2	1	$1^\times$	11	$0^\times$	$0^\times$	$0^\times$	$0^\times$	0	$0^\times$	0	$0^\times$	3	0	$1^\times$	$1^\times$	$2^\times$	$2^\times$	$2^\times$	$3^\times$	$2^\times$	$16^\times$
26	$0^\times$	0	1	2	$2^\times$	3	$2^\times$	3	$14^\times$	$0^\times$	1	1	$1^\times$	$0^\times$	0	$0^\times$	$0^\times$	$5^\times$	$3^\times$	$4^\times$	$4^\times$	$4^\times$	5	$2^\times$	2	$4^\times$	31
27	3	$2^\times$	$2^\times$	$2^\times$	2	2	$2^\times$	2	19	1	0	1	$0^\times$	1	$0^\times$	$0^\times$	0	$4^\times$	$5^\times$	$5^\times$	5	$4^\times$	3	$2^\times$	2	2	30
28	3	2	$2^\times$	2	1	2	$1^\times$	1	15	$0^\times$	1	$1^\times$	$1^\times$	$1^\times$	1	$1^\times$	$0^\times$	9	$0^\times$	$1^\times$	$1^\times$	3	2	$2^\times$	2	$3^\times$	$16^\times$
29	1	1	1	$1^\times$	$1^\times$	$1^\times$	$0^\times$	1	9	1	$2^\times$	3	$1^\times$	2	2	2	$1^\times$	$15^\times$	$3^\times$	4	$3^\times$	$3^\times$	2	$2^\times$	2	$1^\times$	$22^\times$
30	1	1	$0^\times$	1	$1^\times$	1	1	1	8										$3^\times$	2	3	$1^\times$	2	$2^\times$	$1^\times$	4	20
31	1	$0^\times$	$0^\times$	$0^\times$	$1^\times$	2	2	$1^\times$	$9^\times$										$2^\times$	$2^\times$	3	$2^\times$	2	0	$0^\times$	1	14

[a)] Honolulu not reporting March 12-31.

tions. A weighted mean index K_A, is derived from the reduced indices. The reduced indices from Si, Ch, and Wa are given double weight and those from Tu, SJ, Ho, and Hu are given single weight. The weighted indices, K_A, for January to March, 1944, are given in Table 3. A superior cross ($^\times$) following an index-number denotes a half-unit, thus $5^\times = 5.5$, etc.

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington 15, D. C., April 30, 1944

FINAL RELATIVE SUNSPOT-NUMBERS FOR 1943

By W. Brunner

Table 1 contains the final sunspot-numbers for 1943, for the whole disk of the Sun, based on observations made at the Zürich Observatory, supplemented by series furnished by other cooperating observatories for days (indicated by asterisks) on which no observations were possible at Zürich.

Table 2 gives the yearly means of the relative numbers, R, since the last minimum 1933 and the number of days without spots.

Table 1—*Final relative sunspot-numbers for the whole disk of the Sun for 1943*

Day	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1	8	10	46	24[a]*	9	9	0	10	0	15	10	22
2	8	11	38	22	13	7	0	17	0	15	10	21*
3	8	20	16	22	12[a]*	0	0	8[d]	0	17[a]	10	18[a]
4	8*	16	10[d]	30	9*	0	0	8	0	19	9*	17*
5	0*	7	16	24	8	7*	0	18	0	14	8	14[d]*
6	16[d]*	0	19	24[a]	8	0	0	18	0	13	0	21*
7	10*	0*	37	12*	8	0	8[d]	17	*M*19[c]	11	0	29*
8	14	*E*25[c c]	32	14	8	16[d]	16	27[d]	29	10	0	14*
9	12	38	39	19[d]	18*	8*	34	25[a]	31	13*	0	19
10	18*	37	39[b]	26	7	8	32	18	26	10	0	24*
11	14*	37[b]	53	31	7[d]	8	28	19	29	8	0	14*
12	13[a]*	31	46	33	13	8	30	19	22	0	0	12[a]*
13	12	21	44	20	14	19	32[b]	19	0	0*	*E*10[c]*	11[d]*
14	9	29	21	20[a]	17	19[a]	21	26[a d]	0	0	13	28*
15	0	16	29	28[d]	14	14	19	25	0	0	22	32*
16	0	16	11	27	*W*21[c]*	18	17	25	0	0	25	32*
17	11	11	0	32	37[a]	15*	14	32	0	0	25	37*
18	*E*19[c]	*E*15[c]	10[d]	35	47	7	13	41	*M*23[a c]	7	0	48[b]*
19	26	11	11	41	34	0	9	53[a]	20	9	0*	30*
20	21	20[d]	21	36*	20	7	8*	49	13	0	0*	41
21	25[d]	*E*31[c]	*E*37[c]	38[b]	13	0	8*	36	12	0	11[d]*	27
22	25	*M*54[c]	25	45	13	0	8	22	10*	0	15*	22
23	15	62	35	41	10	*M*10[c]	0	20	7	0	13*	22
24	*M*25[c]	60	34[a]	36	10[d]	13	*M*8[c]	9	0	9[d]	15	17*
25	27	63[b]	28[a]	34	10*	10	12	0	0	9*	16	12
26	10	61	25	22	10	10	12	0	9[d]*	9	13[a]	0
27	8	50	24	20[d]	11	8	17[d]	*M*11[c]	11	9*	20	0
28	9	56	20	8	9	7	21	12	13	9*	19*	0
29	7		26*	10	9	0	19	10	13*	14	20	0
30	0		*M*25[c]	10	9	0	16	7	14	11[a]*	21*	0
31	8		33[d]		10		8	0		10		0
Mean	12.4	28.9	27.4	26.1	14.1	7.6	13.2	19.4	10.0	7.8	10.2	18.8

[a]Passage of an average-sized group through the central meridian.
[b]Passage of a large group or spot through the central meridian.
[c]New formation of a center of activity: *E*, on the eastern part of the Sun's disk; *W*, on the western part; *M*, in the central-circle zone.
[d]Entrance of a large or average-sized center of activity on the east limb.

Figure 1 gives a graphical representation of the daily relative sunspot-numbers for 1943, the times being plotted as abscissas and the relative numbers as ordinates. The limits of the successive solar rotations are indicated by vertical arrows in the upper edge of the Figure. The secondary maxima and minima succeeding the rotation-periods do not represent real fluctuations in sunspot-activity, but are rather to be attributed to the influence of solar rotation, to a certain stability of the

centers of activity for spots, and to the special distribution of these centers of activity in the direction of rotation.

Table 2—*Yearly means of relative sunspot-numbers, R*

Year	R	Increase	No. spotless days
1933	5.7		240
1934	8.7	3.0	154
1935	36.1	27.4	20
1936	79.7	43.6	0
1937	114.4	34.7	0
1938	109.6	− 4.8	0
1939	88.8	−20.8	0
1940	67.8	−21.0	0
1941	47.5	−20.3	5
1942	30.6	−16.9	23
1943	16.3	−14.3	65

Figure 2 shows the observed and smoothed monthly relative numbers for 1933 to 1943. The purpose of smoothing is to eliminate the secondary variations. The method of smoothing is as follows: For obtaining the mean of the epoch July 1, the average of the monthly means of the

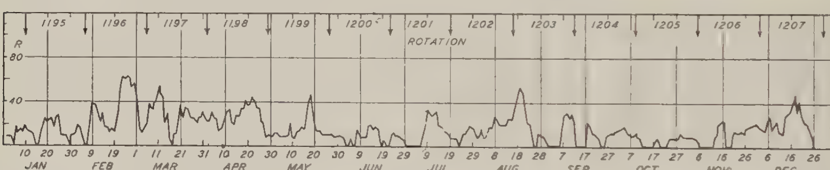


FIG. 1—DAILY RELATIVE SUNSPOT-NUMBERS FOR 1943

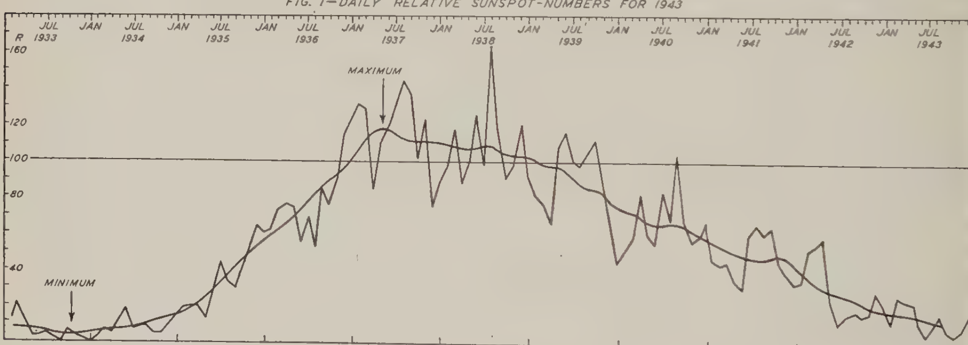


FIG. 2—OBSERVED AND SMOOTHED MONTHLY RELATIVE NUMBERS FOR 1933 TO 1943

twelve months January to December is taken (m_1), and for the epoch August 1, the average of the monthly means for February to January (m_2). The mean of these $m=(m_1+m_2)/2$, which represents the smoothed relative number for the middle of July, is used for the construction of the curve.

Eidgen. Sternwarte,
Zürich, Switzerland, March 14, 1944

LIST OF GEOMAGNETIC OBSERVATORIES AND THESAURUS OF VALUES†—V

By J. A. Fleming and W. E. Scott

Table 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity				
						Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Batavia-Buitenzorg[2, k]—Cont'd	− 6 11	106 49	1902[l]	+ 1 02.4	−30 20.2	36717	36711	+ 666	−21487	42542
			1903	+ 0 59.7	−30 23.6	36696	36690	+ 637	−21524	42543
			1904	+ 0 57.5	−30 33.5	36697	36692	+ 614	−21667	42616
			1905	+ 0 55.0	−30 40.8	36690	36685	+ 587	−21767	42661
			1906	+ 0 54.1	−30 48.8	36708	36703	+ 578	−21894	42741
			1907	+ 0 52.2	−30 55.7	36710	36706	+ 557	−21996	42796
			1908	+ 0 50.7	−31 02.3	36694	36690	+ 541	−22095	42832
			1909	+ 0 49.5	−31 09.6	36682	36678	+ 528	−22180	42867
			1910	+ 0 48.7	−31 12.2	36660	36656	+ 520	−22205	42860
			1911	+ 0 47.7	−31 16.4	36664	36660	+ 508	−22269	42897
			1912	+ 0 47.3	−31 19.4	36683	36679	+ 504	−22324	42942
			1913	+ 0 46.4	−31 24.4	36690	36687	+ 495	−22401	42988
			1914	+ 0 46.2	−31 28.8	36686	36682	+ 492	−22464	43017
			1915	+ 0 46.1	−31 33.6	36676	36673	+ 492	−22528	43042
			1916	+ 0 46.0	−31 38.4	36692	36689	+ 491	−22613	43100
			1917	+ 0 45.9	−31 42.0	36718	36715	+ 490	−22682	43159
			1918	+ 0 46.0	−31 46.2	36716	36713	+ 492	−22738	43187
			1919	+ 0 46.0	−31 50.2	36728	36725	+ 490	−22806	43233
			1920	+ 0 47.0	−31 53.7	36796	36792	+ 503	−22899	43339
			1921	+ 0 47.6	−31 55.8	36820	36816	+ 510	−22945	43385
			1922	+ 0 49.0	−31 57.5	36840	36836	+ 525	−22978	43420
			1923	+ 0 51.4	−31 58.3	36848	36844	+ 551	−23000	43437
			1924	+ 0 52.6	−32 02.8	36839	36835	+ 564	−23062	43462
			1925	+ 0 53.2	−32 06.0	36814	36810	+ 570	−23097	43460
			1926	+ 0 51.6	−32 09.6	36826	36822	+ 553	−23154	43500
			1927	+ 0 52.5	−32 10.5	36853	36849	+ 563	−23185	43540
			1928	+ 0 53.0	−32 14.9	36834	36830	+ 568	−23239	43552
Batavia-Kuyper[2, m]	− 6 11	106 49	1929	+ 0 54.0	−32 13.6	36821	36816	+ 578	−23212	43526
			1930	+ 0 54.7	−32 16.7	36846	36841	+ 586	−23273	43580
			1931	+ 0 58.2	−32 19.4	36863	36858	+ 623	−23325	43622
			1932	+ 1 01.7	−32 21.2	36869	36863	+ 662	−23356	43644
			1933	+ 1 05.3	−32 21.6	36891	36884	+ 700	−23376	43674
			1934	+ 1 08.7	−32 23.0	36946	36939	+ 739	−23432	43750
			1935	+ 1 09.2	−32 20.8	37035	37027	+ 747	−23455	43837
			1936	+ 1 10.9	−32 18.2	37043	37035	+ 764	−23421	43826
			1937	(+ 1 13.9)	(−32 21.0)	(37041)	(37033)	(+ 796)	(−23462)	(43846)
			1938	(+ 1 15.0)	(−32 26.0)	(37039)	(37031)	(+ 808)	(−23536)	(43884)
Dar-es-Salaam[1]	− 6 49	39 18	1903	− 7 35.2	....	.....	.....	......	....	.....
St. Paul de Loanda[1, n] ..	− 8 48	13 13	....	....	....	.....	.....	......	....	.....
Elisabethville[2]	−11 40	27 28	1933[o]	− 9 32.1	−46 01.3	23801	23472	−3943	−24665	34276
			1938	− 9 14.1	....	23573	23267	−3783	....	.....
			1939	− 9 11.4	−46 32.6	23513	23211	−3755	−24815	34185
			1940	− 9 08.8	−46 37.8	23462	23164	−3730	−24837	34166
			1941	− 9 05.8	−46 41.6	23412	23118	−3701	−24838	34133
			1942	− 9 02.6	−46 43.2	23387	23096	−3676	−24835	34113
			1943	− 8 59.6	−46 47.6	23346	23059	−3649	−24855	34100
Huancayo[2, p]	−12 03	284 40	1922[pp]	+ 8 07.6	+ 0 37.5	29735	29436	+4203	+ 324	29737
			1923	+ 8 04.6	+ 0 45.6	29734	29439	+4178	+ 394	29737
			1924	+ 8 01.3	+ 0 54.6	29716	29425	+4147	+ 472	29720
			1925	+ 7 58.3	+ 1 01.9	29696	29409	+4118	+ 535	29701
			1926	+ 7 54.9	+ 1 09.6	29666	29383	+4085	+ 601	29672
			1927	+ 7 50.4	+ 1 17.3	29659	29382	+4046	+ 667	29666
			1928	+ 7 46.1	+ 1 25.8	29646	29374	+4007	+ 740	29655
			1929	+ 7 41.6	+ 1 33.9	29636	29369	+3967	+ 810	29647
			1930	+ 7 36.5	+ 1 42.5	29614	29353	+3921	+ 883	29627
			1931	+ 7 30.8	+ 1 50.3	29624	29370	+3874	+ 951	29639
			1932	+ 7 25.7	+ 1 58.5	29617	29368	+3829	+ 1021	29635
			1933	+ 7 21.4	+ 2 04.7	29614	29370	+3792	+ 1075	29634
			1934	+ 7 18.1	+ 2 08.4	29622	29382	+3765	+ 1107	29643
			1935	+ 7 15.2	+ 2 11.1	29612	29375	+3739	+ 1130	29634
			1936	+ 7 11.6	+ 2 13.5	29609	29376	+3708	+ 1150	29631
			1937	+ 7 08.3	+ 2 15.3	29594	29365	+3678	+ 1165	29617
			1938	+ 7 04.6	+ 2 15.6	29572	29347	+3643	+ 1167	29595
			1939	+ 7 00.4	+ 2 15.1	29554	29333	+3605	+ 1162	29577
			1940	+ 6 55.9	+ 2 14.3	29517	29301	+3562	+ 1154	29540
			1941	+ 6 50.3	+ 2 13.6	29471	29261	+3509	+ 1146	29493
			1942	+ 6 45.3	+ 2 12.5	(29438)	(29234)	(+3463)	(+ 1135)	(29460)
			1943	(+ 6 40.0)	(+ 2 11.5)	(29400)	(29201)	(+3413)	(+ 1125)	(29422)

[k]From magnetograph records at Buitenzorg (latitude −6° 35′, longitude 106° 47′) reduced to Batavia; recording at Batavia discontinued April 1, 1899, because of electric-car disturbances. [l]Six months, July to December, 1902. [m]From magnetograph records at Kuyper (latitude −6° 02′, longitude 106° 44′) reduced to Batavia; in a letter dated November 15, 1941, the Director of the Observatory stated that the published values of 1928-35 (see Preface of "Report on magnetic observations at Batavia," 58B, 1935) are subject to correction because of previous errors in the scale-values and that revised values will be supplied later. [n]Values from absolute observations supplied for the Observatory during 1901 to 1919 show considerable inconsistency and disagreement with those by observers of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington in 1915, 1916, and 1920, and publication in this Thesaurus is deferred pending further examination and report. [o]Polar Year, November, 1932, to August, 1933. [p]These values have been finally corrected on IMS for changes with time in inertia of long magnet of control-magnetometer and supersede those heretofore published in the Annual Reports of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington. [pp]Ten months from March to December, 1922

†Continued from Terr. Mag., **48**, 97-108 (which see for numbered footnotes), 171-182, and 237-242 (1943), **49**, 47-52 (1944).

Table 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Samoa, Apia[2]	−13 48	188 14	1905	+ 9 37.0	−29 11.8	35675	35174	+5960	−19935(?)	40867
			1906	+ 9 38.5	−29 15.7	35655	35151	+5972	−19977	40870
			1907	+ 9 40.1	−29 18.9	35637	35131	+5985	−20010	40871
			1908	+ 9 41.9	−29 21.8	35614	35105	+6000	−20036	40863
			1909	+ 9 43.9	−29 26.5	35587	35075	+6015	−20086	40864
			1910	+ 9 45.6	−29 29.8	35550	35035	+6026	−20110	40843
			1911	+ 9 48.4	−29 36.6	35527	35008	+6051	−20191	40864
			1912	+ 9 49.7	−29 40.6	35493	34972	+6059	−20226	40851
			1913	+ 9 52 0	−29 45.8	35457	34933	+6075	−20277	40845
			1914	+ 9 53.9	−29 49.8	35424	34896	+6089	−20312	40834
			1915	+ 9 57.0	−29 52.8	35386	34854	+6114	−20331	40811
			1916	+10 00.0	−29 54.7	35359	34822	+6140	−20342	40793
			1917	+10 03.2	−29 57.7	35338	34795	+6168	−20371	40789
			1918	+10 06.1	−29 59.4	35315	34767	+6194	−20380	40774
			1919	+10 08.5	−30 01.3	35290	34738	+6213	−20392	40758
			1920	+10 11.2	−30 03.5	35273	34717	+6238	−20413	40754
			1921	+10 10.7	−30 04.3	35257	34702	+6230	−20414	40740
			1922	+10 13.6	−30 05.5	35241	34681	+6257	−20421	40730
			1923	+10 16.3	−30 06.5	35248	34683	+6285	−20440	40746
			1924	+10 19.2	−30 07.5	35249	34679	+6315	−20453	40753
			1925	+10 22.8	−30 07.9	35239	34662	+6349	−20453	40744
			1926[q]	+10 26.2	−30 08.0	35228	34645	+6382	−20449	40733
			1927	+10 29.5	−30 07.0	35223	34634	+6414	−20432	40720
			1928	+10 32.1	−30 05.2	35225	34631	+6440	−20408[r]	40710
			1929	+10 33.5	−30 06.6	35209	34613	+6452	−20418[s]	40701
			1930[t]	+10 34.2	−30 07.9	35195	34598	+6456	−20428	40694
			1931[tt]	+10 35.2	−30 09.3	35171	34572	+6462	−20434	40676
			1932[tt]	+10 34.3	−30 13.6	35116	34520	+6443	−20460	40642
			1933[tt]	+10 34.3	−30 18.4	35095	34499	+6439	−20514	40651
			1934[tt]	+10 34.8	−30 22.4	35048	34452	+6435	−20541	40624
			1935	+10 35.8	−30 27.0	35020	34423	+6440	−20587	40623
			1936	+10 38.4	−30 30.6	35001	34399	+6462	−20626	40626
			1937[u]	+10 41.5	−30 33.5	34939	34332	+6482	−20629	40574
Tananarive[1, v]	−18 55	47 32	1890	−13 07.4	−54 43.0	23030	22429	−5229	−32547	39871
			1891	[−12 55.8]	[−54 45.6]	[23061]	[22476]	[−5160]	[−32643]	[39967]
			1892	−12 44.2	−54 48.3	23092	22524	−5091	−32741	40065
			1893	−12 48.9	−54 55.4	.....	.....	.....	....	.....
			1894	−12 40.7	....	22973	22413	−5042	....	.....
			1902[w]	−10 15.0	−54 06.8	23168	22798	−4123	−32021	39523
			1903	−10 07 0	−54 06.5	23113	22754	−4060	−31939	39425
			1904	− 9 57.9	−54 06.6	23016	22669	−3983	−31807	39261
			1905	− 9 47.9	−54 07.6	22940	22605	−3904	−31721	39147
			1906	− 9 39.2	−54 08.7	22860	22536	−3833	−31632	39028
			1907	− 9 28.9	−54 05.7	22794	22483	−3755	−31483	38868
			1908	− 9 21.6	−54 03.9	22761	22458	−3702	−31403	38784
			1909	− 9 13.0	−53 59.8	22692	22399	−3635	−31229	38603
			1910	− 9 01.3	−53 58.9	22585	22306	−3542	−31065	38407
			1911	− 8 48.6	−53 53.5	22571	22305	−3457	−30943	38300
			1912	− 8 38.9	−53 46.2	22503	22247	−3384	−30713	38075
			1913	− 8 31.4	−53 39.0	22492	22244	−3334	−30563	37947
			1914	− 8 25.2	−53 37.9	22484	22242	−3292	−30532	37917
			1915	− 8 19.2	−53 34.4	22417	22181	−3244	−30376	37752
			1916	− 8 14.0	−53 32.8	22366	22135	−3203	−30277	37642
			1917	− 8 09.1	−53 29.8	22306	22081	−3163	−30141	37497
			1918	− 8 04.2	−53 23.6	22260	22040	−3125	−29966	37329
			1919	− 8 04.6	−53 21.2	22218	21998	−3122	−29866	37224
			1920	− 8 01.5	−53 19.2	22182	21965	−3097	−29781	37134
			1921	− 7 58.0	−53 16.5	22087	21874	−3061	−29605	36936
			1922	− 7 47.2	−53 16.8	22055	21852	−2988	−29568	36888
			1929	− 8 06.7	−53 19.6	21649	21432	−3055	−29073	36249
			1930	− 8 09.0	−53 28.0	21570	21352	−3058	−29115	36235
			1931	− 8 14.0	−53 30.0	21515	21293	−3081	−29076	36171
			1932[x]	− 8 22.0	−53 32.8	21412	21184	−3116	−28986	36037
			1933	− 8 20.0	−53 31.8	21386	21160	−3100	−28934	35980
			1934	− 8 24.0	[−53 38.2]	21326	21097	−3115	[−28965]	[35969]
			1935	− 8 32.0	[−53 40.5]	21248	21013	−3153	[−28899]	[35870]
			1936	[− 8 42.8]	[−53 42.0]	[21225]	[20980]	[−3215]	[−28894]	[35852]
			1937	− 8 51.7	−53 43.9	21194	20941	−3265	−28886	35827
			1938	[− 9 02.8]	[−53 49.0]	[21167]	[20904]	[−3328]	[−28939]	[35854]
			1939	− 9 14.0	−53 54.0	21140	20866	−3392	−28990	35879
			1940	− 9 26.1	−53 53.8	21070	20785	−3454	−28891	35758
			1941	− 9 38.5	−53 54.3	21082	20784	−3531	−28916	35785
Mauritius[2, *]	−20 06	57 33	1899	− 9 32.9	−54 16.8	23854	23524	−3957	−33171	40857
			1900	− 9 29.0	−54 11.0	23826	23500	−3926	−33015	40714
			1901	− 9 21.6	−54 07.6	23809	23492	−3872	−32922	40629
			1902	− 9 16.3	−54 05.0	23750	23440	−3826	−32790	40488
			1903	− 9 14.2	−53 59.4	23682	23375	−3801	−32538	40280

[q]Five international quiet days only in 1926. [r]Five months, January to May, 1928. [s]Six months, July to December, 1929. [t]Six months, January to June, 1930. [tt]Values of *I* during 1931-34 are from absolute observations only and values of *Z* are computed from *I* and *H*, as *Z*-variometer was not operating January, 1931, to July, 1934. [u]Nine months only, January to June and October to December, 1937. The introduction of the new magnetometer and the use of the correction of −28γ from January, 1937, onward result in the published values of *H* being 22γ lower than those of previous years; there is a corresponding drop of 13γ in the published values of *Z*. The difference between the Tesdorpf values (given in previous years) of *D* (reduced to IMS by using correction −3′.0) and those of CIW magnetometer 9 (reduced to IMS using correction −0′.2) was found to be 0′.5; the values of *D* from January onward are therefore higher by this amont (0′.5). [v]Some values taken from graph supplied by Father Poisson, received in October, 1943. [w]Eight months, May to December, 1902. [x]Two months, November and December, 1932.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
Mauritius[2],*—Continued	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
	−20 06	57 33	1904	− 9 14.9	−53 54.5	23631	23324	−3798	−32416	40115
			1905	− 9 11.3	−53 55.5	23584	23281	−3766	−32371	40051
			1906	− 9 12.8	−53 52.9	23527	23223	−3767	−32243	39914
			1907	− 9 13.6	−53 49.0	23463	23159	−3762	−32078	39743
			1908	− 9 14.3	−53 44.9	23415	23111	−3759	−31932	39597
			1909	− 9 16.3	−53 39.8	23377	23072	−3766	−31781	39453
			1910	− 9 18.1	−53 34.7	23327	23020	−3770	−31615	39289
			1911	− 9 18.5	−53 30.6	23310	23003	−3770	−31513	39197
			1912	− 9 25.5[y]	−53 23.2	23304	22989	−3816[y]	−31364	39074
			1913	− 9 30.0	−53 17.9[z]	23282	22963	−3843	−31234	38957
			1914	− 9 34.7	−53 07.6[a]	23256	22932	3870	−31004	38757
			1915	− 9 41.1	−53 00.2[a]	23226	22895	−3907	−30833	38602
			1916	− 9 47.6	−52 54.6	23201	22863	−3946	−30688	38471
			1917	− 9 54.5	−52 48.6	23181	22835	−3989	−30551	38350
			1918	−10 03.2	−52 44.9	23149	22794	−4041	−30447	38248
			1919	−10 10.4	−52 42.8	23112	22749	−4082	−30356	38153
			1920	−10 20.3	−52 40.1	23093	22718	−4144	−30278	38079
			1921	−10 30.7	−52 37.1	23061	22674	−4207	−30185	37986
			1922	−10 39.9	−52 36.2	23019	22621	−4260	−30112	37903
			1923	−10 49.2	−52 33.7	22982	22573	−4314	−30017	37805
			1924	−10 59.7	−52 32.2	22943	22522	−4376	−29940	37720
			1925	−11 09.6	−52 31.0	22906	22473	−4433	−29867	37639
			1926	−11 19.8	−52 33.6	22852	22407	−4489	−29849	37592
			1927	−11 32.0	−52 28.8[b]	22804	22344	−4559	−29697[b]	37442[b]
			1928	−11 42.7	−52 37.0[c]	22768	22294	−4622	−29797[c]	37500[c]
			1929	−11 53.9	−52 37.4[c]	22732	22244	−4687	−29757[c]	37446[c]
			1930	−12 05.5	−52 39.6[d]	22697	22193	−4753	−29750[d]	37420[d]
			1931	−12 17.2	−52 38.3	22673	22154	−4825	−29696	37362
			1932	−12 28.4	−52 42.3	22642	22108	−4890	−29726	37367
			1933[e]	−12 37.2	−52 43.8	22562[f]	22016[f]	−4929[f]	−29649[f]	37257
			1934[g]	−12 50.9	−52 46.5	22542	21978	−5013	−29671	37263
			1935	−12 59.6	−52 48.6	22529	21952	−5065	−29690	37270
			1936	−13 11.3	−52 51.5	22500	21907	−5133	−29706	37264
			1937	−13 22.9	−52 55.8	22471	21861	−5201	−29744	37278
La Quiaca[2]	−22 07	294 25	1920[1]	+ 6 03.3	−12 39.6	26621	26472	+2808	− 5979	27284
			1921[1]	+ 5 57.3	−12 37.9	26557	26414	+2755	− 5949	27215
			1922[1]	+ 5 49.2	−12 30.9	26511	26374	+2688	− 5884	27156
			1923[1]	+ 5 40.2	−12 29.5	26505	26375	+2619	− 5881	27150
			1924[1]	+ 5 33.3	−12 29.3	26481	26357	+2563	− 5863	27122
			1925[1]	+ 5 29.1	−12 28.2	26435	26314	+2527	− 5848	27074
			1926[1]	+ 5 15.0	−12 27.0	26397	26286	+2415	− 5828	27033
			1927[2]	+ 5 05.5	−12 25.7	26353	26249	+2339	− 5808	26985
			1928[2]	+ 4 57.3	−12 26.6	26338	26240	+2275	− 5812	26972
			1929[2]	+ 4 49.0	−12 24.0	26295	26202	+2208	− 5781	26923
			1930[2]	+ 4 40.7	−12 23.8	26266	26178	+2142	− 5774	26893
			1931[2]	+ 4 31.7	−12 22.8	26256	26174	+2073	− 5763	26881
			1932[2]	+ 4 24.2	−12 21.6	26241	26164	+2015	− 5750	26864
			1933[2]	+ 4 16.7	−12 21.2	26223	26150	+1956	− 5743	26845
Vassouras[2] (Succeeding Rio de Janeiro)	−22 24	316 21	1915	−10 28.1	−14 44.1	24700	24289	−4488	− 6496	25540
			1916	−10 39.2	−15 06.8	24663	24238	−4559	− 6661[h]	25547
			1917	−10 50.8	−15 02.2	24644	24204	−4638	− 6620	25518
			1918	−11 02.0[i]	−15 08.2	24564[j]	24110	−4701	− 6645[j]	25447
			1919	−11 10.8	−15 13.5	24504	24039	−4751	− 6669	25395
			1920	−11 17.7	−15 21.6	24494	24020	−4797	− 6728	25401
			1921	−11 25.3	−15 34.1	24475	23990	−4847	− 6819	25407
			1922	−11 34.2	−15 44.2	24430	23934	−4900	− 6884	25381
			1923	−11 42.8	−15 53.7	24407	23899	−4955	− 6950	25377
			1924	−11 53.9	−16 06.0	24371	23847	−5025	− 7034	25366
			1925	−12 03.5	−16 15.6	24333[k]	23796	−5083	− 7097	25347
			1926	−12 10.5	−16 31.2	24293	23747	−5123	− 7205	25339
			1927	−12 19.6	−16 39.7	24276	23716	−5183	− 7265	25340
			1928	−12 28.7	−16 47.4	24221[l]	23649	−5233	− 7308	25299

[y]Subtract 5′.1 for comparison with previous years; thus value for 1912 on basis previous standard would be −9° 20′.4. [z]*I* observed as before with Dover dip-circle 89 using four needles; comparisons of October and November, 1913, with CIW earth-inductor indicate (CIW 4 − Dover 89) = +1′.2. [a]Earth-inductor mounted on western pier of magnetic pavilion and reduced to eastern pier (the one used for dip-circle observations); (*I* on eastern pier − *I* on western pier) = −2′.9. [b]Report states: "Owing to loss of sensitivity of galvanometer of earth-inductor the values given for *I*, *Z*, and *F* are only approximate." [c]Values of *I* for 1928 and 1929 have been revised as apparently the values of *I* were for dip-circle on eastern pier (see footnote for *I* for 1930). [d]In 1930 before return of CIW earth-inductor 4 after repairs by DTM dip-circle 90 was used on eastern pier during January to July, 1930, and after return comparison showed (CIW 4 − 90) = +2′.0; parallel observations with earth-inductor showed (*I* on eastern pier − *I* on western pier) = −5′.6. As earth-inductor is mounted on western pier, values by dip-circle on eastern pier were corrected accordingly to get value for 1930, namely, −52° 39′.6. [e]Eight months only, January to August, 1933, account failure light supply early in September. [f]Discontinuity of about 61γ in *H* caused by introduction of new collimator magnet. [g]Seven months only, June to December, 1934; Observatory was in general overhaul and repairs during 1933 to 1934. [h]No results during May, June, and July, 1916. [i]No results during April and May, 1918. [j]No results during March, April, and May, 1918. [k]No results during June and only 4 days in May and 7 days in July, 1925. [l]No results during January, 1928.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Vassouras[2] (Succeeding Rio de Janeiro)—Continued	−22 24	316 21	1929	−12 34.8	−16 53.4	24175	23595	−5265	− 7340	25265
			1930[m]	−12 42.4	−17 05.2	24146	23555	−5311	− 7422	25261
			1931[n]	−12 49.5	−17 11.3	24112	23510	−5352	− 7459	25239
			1932	−12 57.5	−17 20.6	24069	23456	−5397	− 7517	25216
			1933	−13 04.7	−17 28.6	24040	23416	−5440	− 7569	25203
			1934	−13 11.0	−17 37.8	24010	23377	−5476	− 7630	25193
			1935	−13 17.3	−17 48.4	23977	23335	−5511	− 7701	25183
			1936	−13 23.9	−17 56.1	23956	23304	−5551	− 7754	25180
			1937	−13 29.3	−18 06.3	23906	23247	−5576	− 7816	25151
			1938	−13 36.3	−18 17.6	23859	23190	−5612	− 7888	25129
			1939	−13 41.9	−18 27.5	23819	23141	−5641	− 7950	25111
			1940	−13 47.5	−18 37.4	23767	23082	−5666	− 8009	25080
			1941	−13 53.1	−18 48.3	23709	23016	−5690	− 8074	25046
Rio de Janeiro[2] (Superseded by Vassouras)..	−22 55	316 49	1899	− 7 47.4	−13 15.3	25030[o]	24800[o]	−3390[o]	− 5900[o]	25720[o]
			1900	− 7 55.7	−13 17.1	25040[o]	24800[o]	−3450[o]	− 5920[o]	25730[o]
			1901	− 8 10.0	−13 22.8	25000[o]	24750[o]	−3550[o]	− 5950[o]	25700[o]
			1902	− 8 17.2	−13 22.9	24869	24609	−3584	− 5912	25562
			1903	− 8 27.9	−13 35.4	24798	24528	−3650	− 5987	25510
			1904	− 8 37.5	−13 42.9	24793	24513	−3718	− 6054	25521
			1905	− 8 46.6	−13 51.7	24777	24487	−3781	− 6098	25516
			1906	− 8 55.3	−13 57.2	24772	24472	−3842	− 6169	25529
			1907	(− 8 59.0)	....	.....	.....	......	....	.....
			1909	(− 9 28.0)	....	.....	.....	......	....	.....
			1910	(− 9 40.0)	....	.....	.....	......	....	.....
Watheroo[2, p]..........	−30 19	115 52	1919	− 4 22.8	−63 51.4	24925	24852	−1904	−50780	56567
			1920	− 4 22.1	−63 54.7	24889	24817	−1896	−50832	56598
			1921	− 4 21.6	−63 58.2	24842	24770	−1889	−50865	56607
			1922	− 4 20.9	−64 01.1	24799	24728	−1880	−50885	56606
			1923	− 4 19.5	−64 03.1	24774	24703	−1868	−50910	56618
			1924	− 4 18.2	−64 05.2	24747	24677	−1857	−50935	56629
			1925	− 4 17.6	−64 07.8	24716	24647	−1850	−50969	56646
			1926	− 4 17.2	−64 10.8	24674	24605	−1844	−50995	56651
			1927	− 4 16.3	−64 11.9	24663	24594	−1837	−51016	56665
			1928	− 4 15.0	−64 13.8	24648	24580	−1827	−51053	56692
			1929	− 4 12.1	−64 15.5	24636	24570	−1805	−51095	56724
			1930	− 4 08.0	−64 17.7	24623	24559	−1775	−51151	56769
			1931	− 4 03.3	−64 18.0	24638	24576	−1742	−51193	56813
			1932	− 3 58.4	−64 19.1	24638	24579	−1707	−51237	56853
			1933	− 3 53.4	−64 19.8	24645	24588	−1672	−51279	56894
			1934	− 3 47.8	−64 20.1	24653	24599	−1632	−51307	56923
			1935	− 3 42.5	−64 21.0	24655	24603	−1595	−51344	56957
			1936	− 3 37.0	−64 21.7	24658	24609	−1555	−51376	56987
			1937	− 3 31.7	−64 22.5	24657	24610	−1517	−51406	57014
			1938	− 3 26.3	−64 23.3	24661	24617	−1479	−51445	57050
			1939	− 3 21.0	−64 23.8	24665	24623	−1441	−51471	57076
			1940	− 3 15.8	−64 24.3	24676	24636	−1405	−51514	57119
			1941	− 3 12.3	−64 25.2	24679	24640	−1380	−51556	57158
			1942	− 3 08.2	−64 24.8	24705	24668	−1352	−51593	57203
			1943	(− 3 04.4)	(−64 25.4)	(24718)	(24682)	(−1325)	(−51645)	(57255)
Pilar[2]...............	−31 40	296 07	1905	+ 9 51.7	−26 03.0	25894	25511	+4435	−12657	28822
			1906	+ 9 45.0	−26 01.0	25850	25477	+4378	−12617	28765
			1907	+ 9 38.1	−26 00.7	25805	25441	+4319	−12592	28713
			1908	+ 9 29.1	−25 57.3	25787	25434	+4249	−12552	28680
			1909	+ 9 21.6	−25 55.7	25746	25403	+4187	−12518	28628
			1910	+ 9 13.9	−25 52.8	25694	25361	+4122	−12465	28558
			1911	+ 9 05.4	−25 49.4	25681	25358	+4057	−12428	28530
			1912	+ 8 57.1	−25 45.5	25666	25353	+3994	−12384	28497
			1913	+ 8 49.0	−25 43.7	25635	25332	+3929	−12353	28456
			1914	+ 8 40.4	−25 41.5	25597	25304	+3860	−12315	28405
			1915	[+ 8 31.6]	[−25 41.2]	[25546]	[25264]	[+3788]	[−12287]	[28347]
			1916	+ 8 22.9	−25 40.9	25495	25223	+3716	−12260	28290
			1917	+ 8 13.7	−25 41.0	25450	25188	+3642	−12240	28240
			1918	+ 8 05.5	−25 39.5	25398	25145	+3575	−12200	28176
			1919	+ 7 57.4	−25 40.1	25350	25106	+3509	−12183	28126
			1920	+ 7 48.6	−25 41.2	25297	25062	+3438	−12168	28071
			1921	+ 7 40.2	−25 39.2	25241	25015	+3369	−12122	28001
			1922	+ 7 31.9	−25 39.1	25178	24961	+3300	−12091	27931
			1923	+ 7 23.1	−25 38.4	25139	24930	+3231	−12066	27885
			1924	+ 7 14.4	−25 39.3	25084	24884	+3161	−12048	27827
			1925	+ 7 06.2	−25 41.3	25012	24820	+3093	−12031	27755
			1926	+ 6 58.2	−25 44.0	24934	24750	+3026	−12018	27679
			1927	+ 6 49.6	−25 45.5	24877	24701	+2957	−12004	27622
			1928	+ 6 42.0	−25 46.8	24818	24649	+2896	−11987	27561
			1929	+ 6 34.4	−25 48.2	24763	24600	+2835	−11973	27506

[m]No results during March, 1930. [n]No results during April, May, and June, 1931. [o]Values of H, X, Y, Z, and F given to nearest 10γ. [p]These values have been finally corrected on IMS for changes with time in inertia of long magnet of control-magnetometer and supersede those heretofore published in the Annual Reports of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Pilar[2]—Continued......	−31 40	296 07	1930	+ 6 26.8	−25 50.6	24695	24539	+2773	−11961	27439
			1931	+ 6 18.9	−25 51.2	24661	24511	+2713	−11950	27404
			1932	+ 6 11.4	−25 53.6	24607	24464	+2653	−11945	27353
			1933	+ 6 05.0	−25 55.9	24559	24421	+2603	−11942	27309
			1934	+ 5 59.0	−25 59.2	24516	24382	+2556	−11950	27273
			1935	+ 5 53.5	−26 03.7	24456	24327	+2510	−11961	27224
			1936	+ 5 47.6	−26 07.9	24397	24272	+2463	−11969	27175
			1937	+ 5 41.7	−26 12.5	24335	24215	+2415	−11979	27124
			1938	+ 5 35.9	−26 18.5	24267	24151	+2367	−11998	27071
			1939	+ 5 30.4	−26 24.2	24204	24092	+2323	−12017	27023
			1940	+ 5 24.9	−26 30.0	24137	24029	+2278	−12034	26971
			1941	+ 5 18.5	−26 36.0	24068	23965	+2227	−12052	26917
Santiago[1].............	−33 27	289 18	1902	+14 41.6	−30 55.8	.....	.....	......	....	.....
			1903	+14 36.9	−30 41.6	.....	.....	......	....	.....
			1904	+14 31.3	−30 31.8	.....	.....	......	....	.....
			1905	+14 27.0	−30 25.0	.....	.....	......	....	.....
			1906	+14 18.7	−30 11.8	.....	.....	......	....	.....
			1907	+14 08.7	−29 55.3	.....	.....	......	....	.....
			1908	+14 05.4	−29 55.3	.....	.....	......	....	.....
			1909	+13 57.9	−29 57.2	.....	.....	......	....	.....
Cape Town[2] (Superseded by Hermanus)..	−33 57	18 28	1933	−24 39.9	−63 09.2	15050	13677	−6281	−29733	33325
			1934	−24 36.7	−63 14.9	14955	13596	−6228	−29667	33223
			1935	−24 34.5	−63 21.2	14857	13511	−6179	−29608	33127
			1936	−24 31.2	−63 25.9	14765	13434	−6128	−29525	33011
			1937	−24 28.2	−63 31.1	14674	13356	−6079	−29455	32908
			1938	−24 24.4	−63 35.0	14585	13281	−6026	−29361	32784
			1939	−24 19.8	−63 37.2	14509	13220	−5980	−29254	32654
			1940	−24 16.0	−63 40.2	14433	13158	−5932	−29164	32540
			1941[q]	−24 13.1	−63 42.6	14357	13094	−5889	−29061	32413
Hermanus[2] (Succeeding Cape Town).........	−34 25	19 14	1940[q]	−23 54.5	−63 59.0	14328	13098	−5807	−29352	32663
			1941	−23 51.6	−64 01.4	14252	13034	−5765	−29249	32537
			1942	−23 48.1	−64 03.0	14187	12980	−5724	−29153	32422
Toolangi[r] (Succeeding Melbourne).........	−37 32	145 28	1920[1]	+ 8 00.8	−67 55.1	22874	22651	+3189	−56384	60847
			1921	....	....	.....	.....	......	....	.....
			1922	....	....	.....	.....	......	....	.....
			1923[1]	+ 8 10.7	−67 40.6	22995	22761	+3271	−56013	60549
			1924[2]	+ 8 10.1	−67 42.7	22986	22753	+3266	−56077	60605
			1925[2]	+ 8 10.4	−67 44.5	22948	22715	+3262	−56071	60585
			1926[2]	+ 8 10.9	−67 46.9	22917	22684	+3261	−56107	60607
			1927[2]	+ 8 12.1	−67 47.8	22904	22670	+3267	−56116	60610
			1928[2]	+ 8 14.7	−67 49.4	22891	22654	+3283	−56159	60645
			1929[2]	+ 8 17.5	−67 50.4	22883	22644	+3300	−56183	60664
			1930[2]	+ 8 20.8	−67 51.5	22872	22630	+3320	−56208	60683
			1931[2]	+ 8 24.9	−67 50.8	22884	22638	+3349	−56206	60686
			1932[2]	+ 8 27.8	−67 50.7	22882	22633	+3368	−56199	60679
			1933[2]	+ 8 31.2	−67 50.0	22892	22639	+3392	−56190	60674
			1934[2]	+ 8 33.8	−67 48.8	22907	22652	+3411	−56169	60660
			1935[1]	+ 8 36.7	−67 48.6	22923	22665	+3432	−56199	60694
			1936[2]	+ 8 39.8	−67 48.2	22931	22669	+3454	−56203	60701
			1937[1]	+ 8 43.2	−67 49.4	22913	22648	+3474	−56211	60702
Melbourne[1] (Superseded by Toolangi)...	−37 50	144 58	1896	+ 8 15.0	−67 18.3	23392	23150	+3357	−55936	60630
			1897	....	....	.....	.....	......	....	.....
			1898	+ 8 20.1	−67 22.4	23364	23117	+3387	−56055	60729
			1899[s]	+ 8 25.1	−67 23.1	23323	23072	+3414	−55989	60653
			1900	....	....	.....	.....	......	....	.....
			1901[t]	+ 8 26.7	−67 25.0	23305	23052	+3423	−56033	60686
			1916	+ 8 06.7	−67 48.9	22998	22768	+3245	−56397	60906
			1917	+ 8 03.2	−67 50.9	22961	22735	+3217	−56400	60895
			1918	+ 8 02.6	−67 51.7	22940	22714	+3210	−56386	60874
			1919	+ 8 01.0	−67 53.8	22895	22671	+3193	−56374	60846
			1920	+ 8 00.8	−67 55.1	22874	22651	+3189	−56384	60847
Amberley[2] (Succeeding Christchurch).....	−43 10	172 44	1929	+17 45.0	−67 57.8	22365	21301	+6819	−55252	59607
			1930	+17 51.0	−67 58.4	22351	21275	+6851	−55246	59596
			1931	+17 54.4	−67 57.7	22360	21277	+6875	−55236	59590
			1932	+17 57.3	−67 58.2	22347	21259	+6889	−55227	59577
			1933	+18 00.2	−67 58.7	22339	21246	+6904	−55233	59580
			1934	+18 03.0	−67 59.1	22331	21232	+6919	−55230	59573
			1935	+18 06.3	−67 59.7	22317	21212	+6935	−55224	59562
			1936	+18 09.9	−68 00.5	22301	21190	+6953	−55219	59552
			1937	+18 14.1	−68 01.2	22283	21164	+6973	−55207	59534
			1938	+18 18.8	−68 02.3	22263	21136	+6984	−55198	59518
			1939	+18 24.7	−68 02.5	22255	21116	+7029	−55200	59517
			1940	+18 30.2	−68 03.4	22248	21098	+7060	−55220	59533
			1941	+18 35.9	−68 03.7	22233	21072	+7091	−55220	59527
			1942	+18 42.5	−68 03.9	22233	21058	+7131	−55208	59516

[q]The Cape Town Magnetic Observatory, which was established for the Polar Year 1932-1933, was unsuitable as a permanent observatory owing to magnetic disturbances caused by the electric railways; it was continued in operation until the end of 1940, when the new Observatory at Hermanus was ready for work. Simultaneous observations were taken at both Cape Town and Hermanus in 1940 and the continuity is based upon standard measurements and magnetograms. [r]Observatory reports values of (Toolangi − Melbourne) = +11′.7 in *D*, 176.1γ in *H*, and +17′.8 in *I*. [s]Observations of February 18, March 31, April 4, September 30, and November 30, 1899. [t]Observations of September 20, 1901.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, + =N − =S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Christchurch[2] (Superseded by Amberley)...	−43 32	172 37	1902	+16 15.1	−67 40.8	22694	21787	+6351	−55277	59754
			1903	+16 18.3	−67 42 3	22669	21757	+6364	−55286	59753
			1904	+16 21.8	−67 44.1	22644	21727	+6379	−55307	59763
			1905	+16 25.4	−67 45.8	22628	21705	+6398	−55348	59795
			1906	+16 28.9	....	22599	21670	+6412	....	.....
			1907	+16 31.1	....	.....	.....	......	....	.....
			1908	....	....	.....	.....	......	....	.....
			1909	....	....	.....	.....	......	....	.....
			1910	+16 37.6	−67 54.8	22515	21574	+6442	−55485	59879
			1911	+16 39.0	−67 56.2	22494	21551	+6445	−55497	59882
			1912	+16 42.0	....	.....	.....	......	....	.....
			1913	+16 44.0	−67 58.2	22449	21498	+6463	−55478	59848
			1914	+16 44.8	−67 59.8	22414	21463	+6458	−55465	59823
			1915	+16 47.0	....	22387	21433	+6464	....	.....
			1916	+16 49.8	....	22355	21397	+6473	....	.....
			1917	+16 53.0	−68 04.8	22328	21366	+6485	−55486	59810
			1918	+16 55.7	−68 06.7	22304	21338	+6494	−55516	59829
			1919	+16 58.6	−68 07.8	22280	21309	+6505	−55507	59812
			1920	+17 01.7	−68 09.2	22261	21285	+6519	−55525	59821
			1921	+17 04.6	−68 10.3	22241	21260	+6523	−55528	59816
			1922	+17 08.3	−68 11.2	22217	21230	+6547	−55509	59790
			1923	+17 11.7	−68 12.0	22209	21216	+6566	−55526	59803
			1924	+17 16.4	−68 12.7	22188	21187	+6588	−55508	59778
			1925	+17 21.1	−68 14.2	22166	21157	+6610	−55522	59783
			1926	+17 26.0	−68 15.6	22141	21124	+6633	−55525	59777
			1927	+17 31.3	−68 16.2	22135	21108	+6664	−55538	59787
			1928	+17 37.4	−68 17.3	22126	21088	+6699	−55566	59809
			1929	+17 42.4	−68 17.6	22123	21075	+6730	−55575	59817
			1930	+17 48.3	−68 18.3	22108	21049	+6760	−55570	59806
New Year's Island[2] (Staten Island)......	−54 39	295 51	1902[u]	+15 57.3	−50 13.8	27306	26254	+7505	−32808	42685
			1903	+15 53.7	−50 12.0	27280	26237	+7471	−32742	42617
			1904	+15 49.6	−50 09.6	27226	26194	+7425	−32631	42497
			1905	+15 45.7	−50 06.6	27196	26173	+7387	−32536	42405
			1906	+15 41.6	−50 03.6	27167	26154	+7348	−32443	42315
			1907	+15 38.1	−50 01 7	27135	26131	+7313	−32370	42239
			1908	+15 34.1	−49 58.8	27105	26111	+7275	−32279	42150
			1909	+15 30.3	−49 56.3	27065	26080	+7235	−32185	42052
			1910	+15 26.3	−49 54.2	27040	26064	+7198	−32114[v]	41982
			1911	+15 22.0	−49 50.0	26996	26031	+7154	−31984[w]	41854
			1912	+15 18.1	−49 48.1	26963	26007	+7116	−31908	41775
			1913	+15 14.3	−49 45.8	26924	25977	+7077	−31819	41682
			1914	+15 10.3	−49 43.4	26878	25941	+7034	−31719	41575
			1915	+15 06.6	−49 41.6	26821	25894	+6992	−31619	41462
			1916	+15 02.4	−49 39.4	26771	25854	+6947	−31520	41355
Laurie Island (Orcadas)..........	−60 43	315 13	1905	+ 5 16.6[x]	−54 31.0[y]	25667[z]	25558	+2360	....	.....
			1906	....	(−54 30.6)[a]	(25665)[b]	.....	......	....	.....
			1907	....	(−54 24.4)[c]	.....	.....	......	....	.....
			1908	+ 5 01.3[d]	....	25433[e]	25335	+2226	....	.....
			1909	+ 4 56.6[f]	−54 27.4[g]	25436[g]	25341	+2192	−35603	43756
			1910[h]	(+ 4 54.6)	....	(25431)	(25338)	(+2177)	....	.....
			1911	+ 4 48.8[i]	−54 26.5[j]	25384[k]	25294	+2130		
			1912	+ 4 46.5[2]	−54 26.0[1]	25343[2]	25255	+2110	−35442	43571
			1932 } 1933 } [l]	+ 3 07.8	....	23928	23892	+1307	....	.....
Little America (I)[2].....	−78 35	196 12	1929 } 1930 } [m]	+106 49.1	−82 18.7	8983	2599	+8599	−66541	67145
Little America (II)[1].....	−78 34	196 04	1934 } 1935 } [n]	+106 34.7	−81 53.5	9445	2695	+9053	−66295	66966
Little America (III)[2]....	−78 29	196 09	1940 } 1941 } [o]	+104 54.0	−81 22 4	10038	2581	+9700	−66166	66923

[u]Ten months, March to December, 1902. [v]Nine months, January to September, 1910. [w]Six months, April and August to December, 1911. [x]From magnetograms for February to December, 1905. [y]Absolute values from February to December, 1905. [z]From magnetograms for March to December, 1905. [a]Absolute values from January to August, 1906. [b]From magnetograms for January, 1906. [c]Absolute values for 1907. [d]From magnetograms for April to December, excluding October, 1908. [e]From magnetograms for April to December, excluding September and October, 1908. [f]From magnetograms for March to December, 1909. [g]Absolute values for February to December, excluding September, 1909. [h]January, 1910. [i]From magnetograms for March to December, 1911. [j]Absolute values from February to December, 1911. [k]From magnetograms for June to December, 1911. [l]Polar Year, August 1, 1932, to August 31, 1933 (values submitted in manuscript). [m]The results are based on magnetograms for all days as follows: D, nine months from June, 1929, to February, 1930; H, six months from June, July, August, and December, 1929, and January and February, 1930; Z, seven months from August, 1929, to February, 1930. [n]From monthly mean absolute observations during February 27, 1934, to February 2, 1935. [o]The results are based on magnetograms for all days from May 1, 1940, to January 21, 1941.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
*Corrections and additional results received since publication of Parts I to IV***										
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Bay Tikhaya[2] (Calm Bay)	+80 20	52 48	1937	+22 08.0	+83 14.7	6472	5995	+2438	+54647	55029
			1938	+22 20.3	+83 16.7	6442	5959	+2448	+54656	55034
			1939	+22 36.8	+83 18.5	6415	5922	+2467	+54680	55055
			1940	+22 54.3	....	....	....	......	....	.....
Chelyuskin[2, p]	+77 43	104 17	1935	**	**	**	**	**	**	57789
			1936	**	**	**	**	**	**	57723
			1939	+25 02.2	+86 09.5	3892	3526	+1647	+57958	58089
Dickson[2]	+73 30	80 25[q]	1936	**	+83 11.6	**	**	**	+56834	57237
			1937	+28 47.1	+83 13.5	6744	5911	+3247	+56761	57160
			1938	+28 51.9	+83 16.2	6708	5875	+3238	+56839	57233
			1939	+28 57.3	+83 18.9	6680	5845	+3234	+56993	57383
			1940	+29 05.0	+83 21.9	6648	5810	+3231	+57157	57542
Wellen[2, r]	+66 10	190 10[r]	1937	+15 51.3	+75 39.8	13684	13163	+3739	+53543	55264
			1938	+15 47.1	+75 38.4	13698	13181	+3726	+53506	55232
			1939	+15 41.2	....	13707	13196	+3706	....	.....
Srednikan[2]	+62 26	152 19	1939	− 9 04.1	+73 24.1	16147	15945	−2545	+54169	56524
Yakutsk[2]	+62 01	129 43	1931	−16 05.3	....	14464	13898	−4008	....	.....
			1934	−16 22.8	....	14469	13882	−4080	....	.....
			1935	−16 31.7	....	14469	13871	−4116	....	.....
			1936	−16 40.8	....	14468	13859	−4153	....	.....
			1937	−16 49.1	+75 59.2	14465	13846	−4185	+57960	59738
			1938	−16 54.3	....	14470	13845	−4208	....	.....
			1939	−16 59.6	....	14487	13854	−4234	....	.....
			1940	−17 08.0	....	14500	13857	−4272	....	.....
			1941	−17 14.3	....	14509	13857	−4300	....	.....
			1942	−17 19.9	....	14524	13865	−4327	....	.....
Slutsk[2, s]	+59 41	30 29	1936	+ 4 45.6	+72 05.7	**	**	+1273	+47466	49882
			1937	+ 4 51.9	+72 08.9	15306	15251	+1298	+47527	49931
			1938	+ 4 58.7	+72 11.7	15280	15222	+1326	+47575	49969
			1939	+ 5 04.9	+72 14.1	15260	15200	+1352	+47631	50016
			1940	+ 5 11.7	+72 16.6	15240	15177	+1380	+47686	50062
Sitka[t]	+57 03	224 40	1902[4]	+29 51.1	+74 47.8[tt]	15441	13393	+7685	+56822[tt]	58883[tt]
			1903[4]	+29 53.9	+74 46.3[tt]	15457	13400	+7704	+56777[tt]	58844[tt]
			1904[4]	+29 55.8	+74 45.4[tt]	15475	13412	+7721	+56789[tt]	58860[tt]
			1905[4]	+29 59.1	+74 43.2	15494	13421	+7744	+56719	58797
			1906[4]	+30 03.0	+74 41.0	15513	13429	+7768	+56641	58727
			1907[4]	+30 07.1	+74 38.4	15529	13434	+7792	+56537	58631
			1908[4]	+30 10.6	+74 36.5	15546	13440	+7815	+56474	58576
			1909[4]	+30 13.1	+74 34.6	15560	13447	+7832	+56406	58512
			1910[4]	+30 16.4	+74 32.2	15577	13454	+7853	+56312	58426
			1911[4]	+30 19.1	+74 30.4	15590	13459	+7870	+56242	58362
			1912[4]	+30 20.9	+74 28.8	15599	13462	+7882	+56175	58300
			1913[4]	+30 22.0	+74 27.7	15606	13465	+7890	+56128	58256
			1914[4]	+30 22.9	+74 26.6	15605	13462	+7892	+56055	58187
			1915[4]	+30 23.2	+74 26.5	15593	13451	+7887	+56008	58138
			1916[4]	+30 23.9	+74 25.6	15585	13443	+7887	+55923	58055
			1917[4]	+30 24.7	+74 24.8	15584	13439	+7889	+55866	57999
			1918[4]	+30 24.9	+74 23.8	15580	13436	+7887	+55790	57925
			1919[4]	+30 26.7	+74 23.2	15578	13430	+7894	+55748	57884
			1920[4]	+30 28.2	+74 22.1	15574	13423	+7898	+55662	57800
			1921[4]	+30 28.5	+74 22.6	15570	13419	+7897	+55679	57816
			1922[4]	+30 29.1	+74 22.4	15560	13409	+7894	+55631	57766
			1923[4]	+30 28.9	+74 21.9	15552	13403	+7889	+55573	57708
			1924[4]	+30 28.6	+74 21.9	15540	13393	+7882	+55523	57656
			1925[4]	+30 27.0	+74 22.0	15528	13386	+7869	+55491	57622
			1926[4]	+30 24.7	+74 22.4	15510	13376	+7852	+55451	57580
			1927[4]	+30 22.6	+74 22.3	15497	13370	+7837	+55399	57525
			1928[4]	+30 20.0	+74 22.4	15485	13365	+7820	+55357	57482
			1929[4]	+30 17.3	+74 22.4	15473	13361	+7804	+55318	57441
			1930[4]	+30 15.2	+74 22.3	15461	13355	+7789	+55267	57388
			1931[4]	+30 13.0	+74 21.2	15459	13358	+7780	+55195	57319
			1932[4]	+30 11.0	+74 20.7	15456	13361	+7770	+55155	57280
			1933[4]	+30 08.3	+74 20.2	15456	13367	+7760	+55125	57251
			1934[4]	+30 05.4	+74 20.2	15457	13374	+7750	+55128	57254
			1935[4]	+30 02.6	+74 19.8	15456	13379	+7738	+55092	57219
			1936[4]	+30 00.1	+74 19.5	15452	13381	+7726	+55060	57187

**Corrected values are indicated only for the particular element concerned; double asterisks (**) in column indicate values as previously published are correct.

[p]N. Pushkov indicates this station is more properly designated Cape Chelyuskin. [q]N. Pushkov gives longitude as 80° 25′ instead of 80° 24′ as published on p. 99, Terr. Mag., **48**. [r]N. Pushkov gives longitude as 190° 10′ instead of 190° 09′ as published on p. 99, Terr. Mag., **48**, and Wellen as preferred English spelling. [s]N. Pushkov gives Slutsk as preferred English spelling; entry (Pavlovsk) as alternate name on p. 100, Terr. Mag., **48**, should be deleted. [t]See footnote [b] for Cheltenham on p. 237, Terr. Mag., **48**. [tt]There was no Z-variometer during 1902, 1903, and 1904; values depend on absolute results with dip-circle.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Sitka—Continued	+57 03	224 40	1934[t]	+30 05.4	+74 20.2	15457	13374	+7750	+55128	5725
			1935[t]	+30 02.6	+74 19 8	15456	13379	+7738	+55092	5721
			1936[t]	+30 00.1	+74 19.5	15452	13381	+7726	+55060	5718
			1940[2u]	(+29 45.3)	(+74 17.7)	(15482)	(13441)	(+7684)	(+55063)	(5719
Vyssokaya Dubrava[2, v] (Succeeding Sverdlovsk)	+56 44	61 04	1936	+12 52.5	+72 21.1	16177	15770	+3605	+50848	53359
			1937	+12 54.1	+72 24.4	16146	15738	+3605	+50919	53418
			1938	+12 55.4	+72 27.3	16120	15712	+3605	+50984	53472
			1939	+12 56.1	+72 29.5	16103	15694	+3605	+51047	53527
			1940	+12 57.2	+72 31.9	16085	15676	+3606	+51116	53583
			1941	+12 58.9	+72 34.6	16066	15655	+3609	+51195	53657
			1942	+12 59.4	+72 36.1	16060	15649	+3610	+51254	53711
Zaimishche[2, w]	+55 50	48 51	1936	+ 9 18.0	+70 57.7	16754	16534	+2708	+48552	51361
			1937	+ 9 20.3	+71 01.3	16726	16504	+2714	+48634	51430
			1938	+ 9 23.9	+71 04.6	16701	16477	+2727	+48715	51498
			1939	+ 9 25.8	+71 07.3	16678	16453	+2733	+48774	51547
			1940	+ 9 27.5	+71 10.4	16651	16425	+2736	+48836	51597
			1941	+ 9 30.6	+71 13.1	16627	16398	+2747	+48892	51642
			1942	+ 9 32.2	+71 14.6	16610	16380	+2752	+48913	51656
Meanook	+54 37	246 40	1916[1,x]	+27 48.6	+77 55.9	.....	.....	......	....	.....
			1917[1,y]	**	+77 55.0	12941	11450	+6029	+60449	61819
			1938	+25 54.8	+77 52.7	12726	11446	+5562	+59252	60603
			1939	+25 51.6	+77 53.2	12710	11438	+5544	+59224	60573
			1940	+25 45.0	+77 52.6	12718	11455	+5526	+59210	60561
			1941	+25 38.7	+77 52.5	12717	11464	+5504	+59196	60547
			1942	+25 33.6	+77 51.8	12729	11482	+5492	+59188	60541
Zuy[2, z]	+52 28	104 02	1936	− 0 09.5	+71 26.3	18992	18992	− 52	+56560	59663
			1937	− 0 14.6	+71 27.8	18981	18981	− 81	+56606	59704
			1938	− 0 20.0	+71 29.0	18978	18978	− 110	+56664	59758
			1939	− 0 25.0	+71 29.6	18984	18983	− 138	+56718	59811
			1940	− 0 30.0	+71 29.9	18996	18995	− 166	+56770	59864
			1941	− 0 34.9	+71 31.0	18997	18996	− 193	+56829	59920
			1942	− 0 39.1	+71 30.6	19020	19019	− 216	+56879	59975
Nizhnedevitsk[2]	+51 31	38 22	1936	+ 5 39.7	+67 38.2	18556	18465	+1831	+45104	48772
			1937	+ 5 43.2	....	.....	.....	......	....	.....
			1938	+ 5 46.2	....	.....	.....	......	....	.....
			1939	+ 5 49.5	....	.....	.....	......	....	.....
			1940	+ 5 54.0	....	18472	18374	+1899	....	.....
Janów	+49 54	23 44	1933	**a	**	**	**	**	**	**
Eastport[1, b]	+44 54	293 01	1860	−17 57.1[c]	+75 53.1	15230[b]	14490[b]	−4690[b]	+60570[b]	62450[b]
			1861	−17 59.2	+75 51.0	15230[b]	14490[b]	−4700[b]	+60410[b]	62300[b]
			1862	−18 00.6	+75 48.5	15210[b]	14460[b]	−4700[b]	+60150[b]	62040[b]
			1863	−18 02.3	+75 48.3	15240[b]	14490[b]	−4720[b]	+60250[b]	62150[b]
			1864[d]	−18 03.7	+75 46.3	15260[b]	14510[b]	−4730[b]	+60180[b]	62090[b]
Agincourt	+43 47	280 44	1938	− 7 35.1	+74 51.3	15310	15176	−2021	+56564	58599
			1939	− 7 33.8	+74 51.7	15292	15159	−2013	+56525	58556
			1940	− 7 32.3	+74 51.5	15290	15158	−2006	+56503	58535
			1941	− 7 32.4	+74 51.3	15288	15156	−2006	+56482	58514
			1942	− 7 31.4	+74 50.0	15303	15171	−2004	+56460	58497
Toulouse[1, e]	+43 37	1 28	1903	**	**	** e	**	**	**	**
Mai-Tun[2, f] (Succeeding Vladivostok)	+43 15	132 20	1941[g]	− 8 40.9	+58 57.7	26826	26519	−4049	+44579	52028
			1942[h]	− 8 42.2	+58 55.4	26875	26566	−4067	+44592	52064

[u]There are artificial jumps at the beginning of 1940 because of (a) change of site of absolute instruments and (b) change of *I*-standard; to get comparable values in estimating secular changes following values should be applied from 1940: *D*, +5′.1; *H*, −29γ; *Z*, −72γ. [v]N. Pushkov gives Vyssokaya Dubrava as preferred English spelling; this Observatory was transferred from Sverdlovsk in 1929. [w]N. Pushkov gives Zaimishche as the preferred English spelling. [x]Four months from September to December, 1916. [y]Three months from October to December, 1917. [z]N. Pushkov gives Zuy as the preferred English spelling. [a]Footnote [h] on p. 176, Terr. Mag., **48**, should read "eight months." [b]Values of *H* derived from original publications with a correction of −0.001 *H* to reduce them to IMS adopted in 1913 by United States Coast and Geodetic Survey; values of *F*, under the requirement that they must conform with those of *I* and *H*, embody a similar correction; intensity-components given only to nearest 10γ. [c]Five months only from August to December, 1860, but value is reduced to mean of year 1860. [d]Seven months only from January to July, 1864, but value is reduced to mean of year 1864. [e]On p. 179, Terr. Mag., **48**, the footnote for value of *H* for 1903 should be [f] instead of [g] and footnote [g] should be eliminated. [f]Mai-Tun replaced Vladivostok January 1, 1938. [g]Three months, January to March, 1941. [h]Seven months, January to July, 1942.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, D	Inclination, I	Components of intensity: Horizontal, H	North, X	East, Y	Vertical, Z	Total, F
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Dusheti[2, i] (Succeeding Karsani)	+42 05	44 42	1938	+ 4 55.7	+59 14.7	24135	24046	+2073	+40558	47196
			1939	+ 4 55.4	+59 17.2	24144	24055	+2072	+40641	47272
			1940	+ 4 56.2	+59 21.3	24142	24052	+2078	+40749	47364
			1941	+ 4 59.7	+59 25.0	24144	24052	+2102	+40852	47453
Karsani[2] (Superseded by Dusheti)	+41 50	44 42	1934	+ 4 26.0	+58 41.2	24570	24496	+1899	+40390	**
Keles[2, j] (Succeeding Tashkent)	+41 25	69 12	1936[jj]	+ 5 23.5	+60 11.9	25359	25247	+2383	+44276	51024
			1937	+ 5 21.2	+60 13.1	25369	25258	+2367	+44330	51076
			1938	+ 5 19.3	+60 15.2	25371	25262	+2353	+44395	51133
			1939	+ 5 16.4	+60 16.0	25394	25287	+2334	+44460	51201
			1940	+ 5 13.2	+60 16.2	25419	25314	+2313	+44509	51256
			1941	+ 5 10.8	+60 18.3	25437	25333	+2297	+44604	51347
			1942	+ 5 07.7	+60 18.2	25474	25372	+2277	+44666	51420
Tashkent[2]	+41 20	69 18	1928[k]	**	**	**	**	**	**	**
Coimbra[1]	+40 12	351 35	1938	−12 47.7	+57 18.4[l]	23361	22781	−5174	+36398	43250
			1939	−12 41.3[m]	+57 17.5[n]	23394[m]	22823	−5138	+36428	43293
Washington[2] (Old Naval Observatory site)	+38 54	282 57	1888	− 3 58.8	....	.....	.....	......	....	....
			1889	− 4 01.5	+71 06.0	19869	19820	−1395	+58033	61340
			1890	− 4 05.7	+71 04.5	19860	19809	−1418	+57928	61238
			1891	− 4 09.7	+71 05.1	19855	19803	−1441	+57940	61248
			1892	− 4 14.2[o]	+71 03.9	19848[o]	19794	−1466	+57858[o]	61168
Washington[p]	+38 53	283 00	1867	− 2 48.1	+71 06.7	19900	19880	− 970	+58160	61470
			1868	− 2 51.2	+71 03.4	19960	19940	− 990	+58150	61490
			1869[q]	− 2 53.0	+70 57.9	20020	19990	−1010	+58030	61380
Baldwin[2, 4, r] (Superseded by Tucson)	+38 47	264 50	1901[2]	+ 8 21.9	+68 34.5[s]	21931	21698	+3190	+55890[s]	60038[s]
			1901[4]	+ 8 21.9	....	21931	21698	+3190	....	.....
			1902[2]	+ 8 23.0	+68 37.6[s]	21926	21692	+3197	+56025[s]	60163[s]
			1902[4]	+ 8 23.0	....	21926	21692	+3197	....	.....
			1903[2]	+ 8 24.8	+68 40.0[s]	21890	21654	+3203	+56049[s]	60172[s]
			1903[4]	+ 8 24.8	....	21893	21657	+3203	....	.....
			1904[2]	+ 8 26.4	+68 40.6[s]	21854	21617	+3208	+55985[s]	60099[s]
			1904[4]	+ 8 26.3	....	21856	21619	+3207	....	.....
			1905[2]	+ 8 27.7	+68 43.1	21818	21580	+3210	+56015	60114
			1905[4]	+ 8 27.6	+68 43.0	21821	21584	+3210	+56014	60114
			1906[2]	+ 8 29.7	+68 44.4	21786	21547	+3218	+55992	60081
			1906[4]	+ 8 29.7	+68 44.3	21788	21549	+3219	+55992	60082
			1907[2]	+ 8 31.6	+68 46.5	21737	21497	+3223	+55970	60043
			1907[4]	+ 8 31.4	+68 46.2	21742	21502	+3222	+55970	60045
			1908[2]	+ 8 33.0	+68 48.0[s]	21686	21445	+3224	+55910[s]	59968[s]
			1908[4]	+ 8 33.0	....	21692	21451	+3225	....	.....
			1909[2, t]	+ 8 34.0	+68 50.6[s]	21635	21394	+3223	+55906[s]	59946
			1909[4, t]	+ 8 34.0	+68 50.2[s]	21644	21403	+3224	+55908[s]	59951[s]
Cheltenham[2, 4, tt]	+38 44	283 10	1933[4]	− 7 06.2	+71 12.4	18438	18296	−2280	+54184	57235
			1934[4]	− 7 06.8	+71 14.1	18387	18246	−2277	+54117	57155
San Miguel (Ponta Delgada)	+37 46	334 21[u]	**	**	**	**	**	**	**	**
Tucson[2, 4]	+32 15	249 10[v]	**	**	**	**	**	**	**	**

[i]Dusheti replaced Karsani in 1935. [j]Keles replaced Tashkent in 1935. [jj]Four months, September to December, 1936. [k]Six months from January to June, 1928. [l]No I in November, 1938. [m]Nine months, January to July, November, and December, 1939. [n]One month, July, 1939. [o]Nine months in D from January to September and seven months in H and Z from January to July, 1892—observations incomplete because instruments were dismounted for removal to New Naval Observatory. [p]Based on absolute observations only on the 14th, 15th, and 16th of each month; those for D included readings at quarter-hour intervals for two periods of the day intended to cover, respectively, the morning and afternoon extremes; values of H are derived from tabulations in the Annual Report of the United States Coast and Geodetic Survey for 1869 (Appendix 9) with a correction of $-0.001H$ to reduce them to IMS adopted in 1913; values of intensity-components given to nearest 10γ. [q]Six months from January to June, 1869. [r]The values for all days are final revisions and replace those published on p. 182, Terr. Mag., **48**; the elements I, Z, and F are not known with sufficient accuracy because of difficulty with the dip-circle. The values of H are derived from tabulations in original publications with a correction of $-0.001\ H$ to reduce them to IMS adopted in 1913, and values of Z and F, under the requirement that they must conform with those of I and H, embody similar corrections. Tucson replaced Baldwin in October, 1909. [s]Values of I for 1901-04 were obtained from absolute observations and averaged for each month and entries for I, Z, and F are based on these monthly means; the same is true for February to August, 1908, and for October, 1909. [t]Ten months, January to October, 1909. [tt]Values for all days given on p. 237, Terr. Mag., **48**, are final; see footnote [b] re IMS on p. 237, Terr. Mag., **48**. [u]Longitude for San Miguel is 334° 21′ and not 234° 21′ as given on p. 238, Terr. Mag., **48**. [v]Longitude for Tucson is 249° 10′ and not 239° 10′ as given on p. 240, Terr. Mag., **48**.

TABLE 1—*Annual values of geomagnetic elements at observatories*—Continued

Observatory	Latitude, +=N −=S	Longitude, east	Year	Declination, *D*	Inclination, *I*	Components of intensity: Horizontal, *H*	North, *X*	East, *Y*	Vertical, *Z*	Total, *F*
	° ′	° ′		° ′	° ′	γ	γ	γ	γ	γ
Helwan	+29 52	31 20	1903[1,w]	− 3 22.4	+40 31.2	30107	30055	−1772	+25732	39605
			1904[1,w]	− 3 18.4	+40 34.3	30063	30013	−1734	+25741	39578
			1905[1,w]	− 3 13.8	+40 36.3	30061	30013	−1694	+25770	39595
			1906[1,w]	− 3 06.1	+40 38.4	30067	30023	−1627	+25807	39624
			1935	**	**	**	**	**	**	40653
			1936[2,x]	**	+41 58.6[x]	**	**	**	+27257[x]	40754
			1937[1,x]	**	+42 00.9[x]	**	**	**	+27328[x]	40829
Key West[1,y]	+24 33	278 12	1860[z]	+ 4 46.6	+54 37.8	31110	30990	+2590	+43810	53730
			1861[a]	+ 4 44.5	+54 36.8	31090	30980	+2570	+43770	53690
			1862[b]	+ 4 39.9	+54 31.0	31060	30960	+2530	+43570	53510
			1863	+ 4 36.8	+54 31.2	31050	30950	+2500	+43560	53500
			1864	+ 4 33.9	+54 29.0	31040	30940	+2470	+43490	53430
			1865	+ 4 31.5	+54 28.8	31000	30900	+2450	+43430	53360
			1866[c]	+ 4 29.8	+54 28.7	30980	30880	+2430	+43400	53320
Cuajimalpa[1,d] (Superseded by Teoloyucan)	+19 20	260 50	**	....	....	.....	.....	......	....	.....
Vieques[2] (Superseded by San Juan)	+18 09	294 33	1911	**	**	28735	**	**	**	**
Toolangi (Succeeding Melbourne)	−37 32	145 28	1940[1,e]	+ 8 54.5	−67 49.5	22919	22643	+3549	−56229	60721
			1941[1,f]	+ 8 56.6	−67 53.1	22886	22608	+3558	−56319	60791
			1942[1,g]	+ 8 57.3	−67 50.7	22897	22618	+3564	−56234	60717
			1943[1,h]	+ 9 02.2	−67 51.1	22896	22612	+3596	−56249	60730

[w]Revised values after correcting those on p 242, Terr. Mag., **48**, and p. 47, Terr. Mag., **49**, by application of changes based on "The standardization of the magnetic instruments at Helwan Observatory during 1907," by H. E. Hurst, namely, in D $-0'.9$, in H -98γ, and corresponding changes in other elements; note that values of D for 1903, 1904, and 1905, on p. 242, Terr. Mag., **48**, were also revised to $-3°\ 21'.5$, $-3°\ 17'.5$, and $-3°\ 12'.9$ before application of $-0'.9$ as above. [x]A Dye Z-magnetometer was adopted as standard from January, 1936, and comparison between values of I as obtained with dip-circle and two needles and that derived by the Dye instrument showed the latter to be in excess of the former by $+1'.33$; on p. 47, Terr. Mag., **49**, there should accordingly have been a rule between the entries for 1935 and 1936 at Helwan. The values here given are those of 1936 and 1937 suitably corrected to refer those years as a continued homogeneous series with years prior to 1936 by application to the values given on p. 47, Terr. Mag., **49**, corrections in I of $-1'.3$, in Z of -21γ, in F of -14γ, while D, H, X, and Y remain unchanged. It is to be noted that for 1936 the values for elements are from magnetograms for all days excluding, however, those days when disturbance in H exceeded 100γ, while the values for 1937 are from means of absolute observations. [y]Based on absolute observations made generally on four days of each month with those for D corrected for diurnal variation; values of H derived from original publications with a correction of $-0.001\ H$ to reduce them to IMS adopted in 1913 by United States Coast and Geodetic Survey; values of F, under the requirement that they must conform with those of I and H, embody a similar correction. Values of intensity-components given to nearest 10γ. [z]In 1860 results depend on absolute observations during four months of February, March, June, and December for D, during four months of March, May, June, and December for H, and during six months of February, March, May, June, August, and December for I. [a]In 1861 results depend on absolute observations during three months of February, March, and April for D, and during three months of January, March, and May for I and H. [b]In 1862 results depend on absolute observations during eight months from May to December. [c]In 1866 results depend on absolute observations during four months from January to April. [d]Six months from July to December, 1911. [e]Mean of 15 absolute observations in 1940. [f]Mean of 10 absolute observations of D and H, and 8 absolute observations of I, in 1941. [g]Mean of 13 absolute observations in 1942. [h]Mean of 12 absolute observations in 1943.

(*To be continued in September, 1944, number*)

ATMOSPHERIC-ELECTRIC OBSERVATIONS AT HUANCAYO, PERU, DURING THE SOLAR ECLIPSE, JANUARY 25, 1944

By M. W. Jones and A. A. Giesecke

Introduction

During the solar eclipse of January 25, 1944, ($08^h\ 04^m$ to $10^h\ 44^m$) which reached 88 per cent totality at Huancayo, Peru, at $09^h\ 18^m$, it seemed desirable that the Huancayo Magnetic Observatory (latitude 12° 02′.7 south, longitude 75° 20′.4 west, altitude 3300 meters) of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, make special observations of several components of the geophysical program of the Observatory. These included observations of the potential-gradient of the atmosphere, positive and negative conductivity, and nuclei-count. A description of the method for measurement of the potential-gradient and the conductivity can be found elsewhere [see 1 of "References" at end of paper]. Jones and Ledig [2] have shown that in the early morning hours at Huancayo there is a variation in potential-gradient and conductivity which may be attributed to heating effects of the Sun. It appeared that during a solar eclipse interesting data would be obtained due to the variation in heating effect on the lower strata of the atmosphere. An increase in heating decreases the stability of this lower stratum and causes a mixing of this layer with higher strata, gradually bringing in more nuclei and consequently decreasing the conductivity of the air. The reverse would be expected during a solar eclipse.

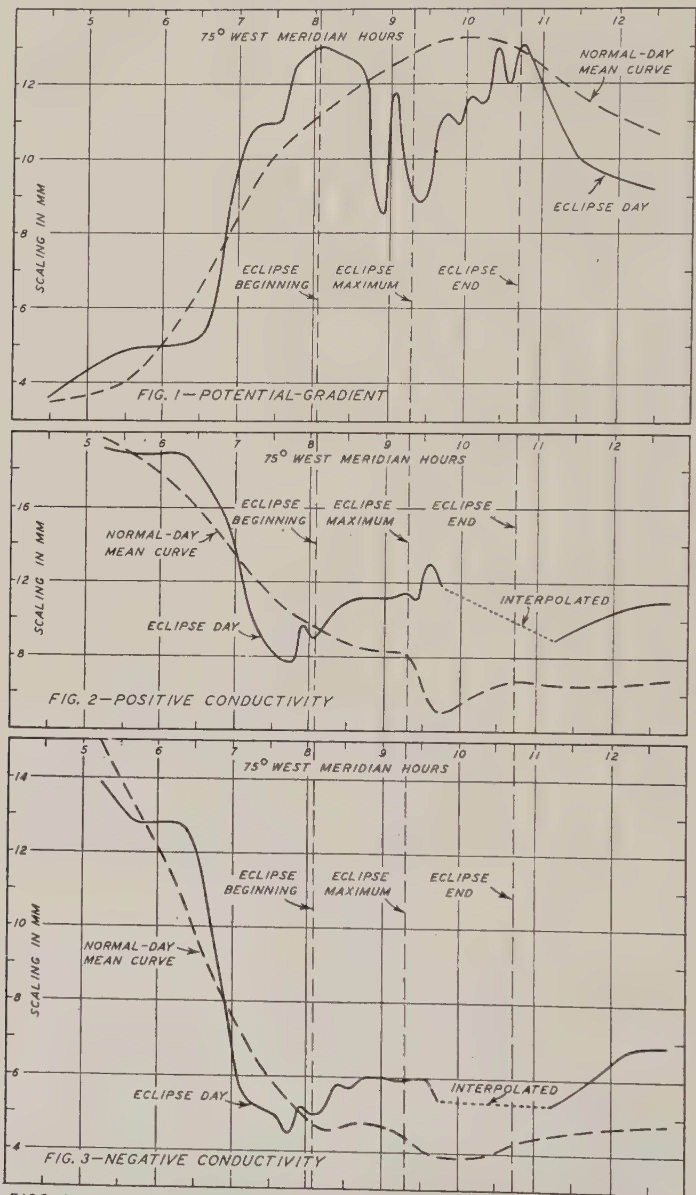
Results of measurements

(1) *Potential-gradient*—Figure 1 portrays the variation of the potential-gradient values on the day of the eclipse with those of the means of four normal control-days; two before and two after the day of the eclipse. The normal diurnal variation is seen to be a smooth increase until approxmately 10^h (75° west MT), and then followed by a smooth decrease. During the day of the eclipse the rise in potential-gradient conformed to the normal variation until the time of the beginning of the eclipse. At this point the potential-gradient decreased in a gradual manner until $08^h\ 36^m$, and then sharply to a minimum reached a little before 09^h. Shortly after the maximum of the eclipse another minimum value was reached in potential-gradient followed by an increase to a maximum until the end of the eclipse. Thereafter the variation was normal.

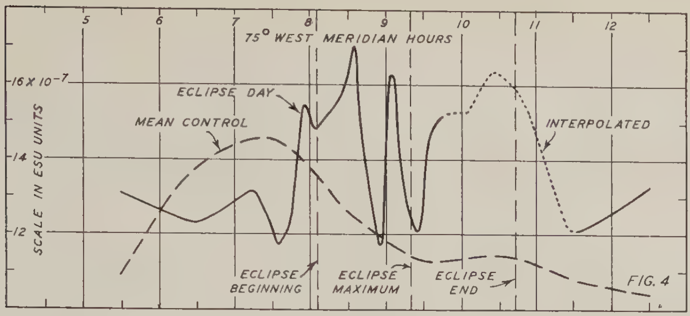
(2) *Conductivity*—Figures 2 and 3 illustrate the variation from normal of the positive and negative conductivity of the atmosphere during the day of the eclipse. In the case of the positive conductivity, the decrease during the hours preceding the eclipse is in accord with the normal variation and with the increase in temperature. An immediate gradual rise in value was observed at the beginning of the eclipse. A slight decrease and a sharp increase was noted shortly after the maximum of the eclipse. Unfortunately the values of both the positive conductivity and the negative conductivity after $09^h\ 45^m$ were lost because of difficulties with the high-speed clock-driving mechanism of the automatic recorder. It is assumed, however, that following the maximum reached after the maximum of the eclipse a gradual decrease occurred and linear interpolation was made for the values during this interruption. In the

case of the negative conductivity the results closely paralleled those of the positive conductivity.

(3) *Air-earth current-density*—Figure 4 shows the variation from normal of air-earth current-density during the day of the eclipse, as



FIGS. 1, 2, AND 3—ATMOSPHERIC-ELECTRIC ELEMENTS DURING SOLAR ECLIPSE OF JANUARY 25, 1944, AND NORMAL-DAY MEANS, HUANCAYO MAGNETIC OBSERVATORY



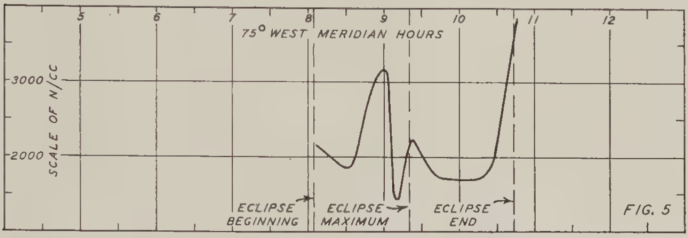


FIG. 4—AIR-EARTH CURRENT DENSITY DURING SOLAR ECLIPSE OF JANUARY 25, 1944, AND MEAN CONTROL, HUANCAYO MAGNETIC OBSERVATORY
FIG. 5—AITKEN NUCLEI-COUNT DURING SOLAR ECLIPSE OF JANUARY 25, 1944, HUANCAYO MAGNETIC OBSERVATORY

computed from the atmospheric conductivity and the potential-gradient. An anomalous variation occurred shortly after $07^{h}\ 30^{m}$, approximately one-half hour before the beginning of the eclipse. The value of the current rose sharply, then decreased slightly only to continue to rise at the time of the beginning of the eclipse. Many abrupt variations in value followed with an approximate mean value of 14.5×10^{-7} ESU. A decrease in value followed the end of the eclipse.

Table 1 summarizes the data obtained.

(4) *Nuclei-count*—Figure 5 shows the variation of nuclei-count taken at approximately 15-minute intervals during the eclipse. The instrument used for these counts was a standard Aitken pocket nuclei-counter (DTM No. 4). The count decreased gradually during the eclipse until shortly before the end when it rose abruptly to high values.

The above results indicate a large effect of solar heating on the lower atmospheric regions and resultant turbulent mixing of very low air-strata with higher strata.

Summary

The chief effects in potential-gradient, air-conductivity, and nuclei-count at Huancayo Magnetic Observatory, associated with the partial solar eclipse of January 25, 1944, were: (*a*) The potential-gradient decreased in value during the eclipse; (*b*) the positive and negative conductivity increased; (*c*) air-earth current-density, as computed from values of the potential-gradient and conductivity, increased; (*d*) the nuclei-count of the atmosphere decreased. These effects are attributed to corresponding variations in the solar heating of the lower strata of the atmosphere.

TABLE 1—*Atmospheric-electric observations during eclipse of January 25, 1944, at Huancayo Magnetic Observatory*

Time, 75°WMT	Potential-gradient, in v/m	Air-conductivity in 10^{-4} ESU			Air-earth current-density[a] in 10^{-7}ESU
		λ_+	λ_-	$(\lambda_+ + \lambda_-)$	
	A—Normal control-day means				
04^h–05^h	25.4	...	...	....	....
05 –06	29.0	5.5	5.8	11.3	10.9
06 –07	47.2	4.6	4.2	8.8	13.8
07 –08	74.1	3.3	2.6	5.9	14.6
08 –09	85.7	2.5	1.9	4.4	12.6
09 –10	94.4	1.9	1.7	3.6	11.3
10 –11	95.8	1.9	1.7	3.6	11.5
11 –12	84.9	1.9	1.9	3.8	10.8
12 –13	77.7	2.0	2.0	4.0	10.4
	B—Eclipse-day data				
04 –05	26.1	...	...	....	....
05 –06	35.6	5.4	5.6	11.0	13.1
06 –07	37.8	5.1	4.7	9.8	12.3
07^h00^m–07^h30^m	79.1	2.8	2.2	5.0	13.2
07 30 –07 40	79.9	2.3	2.1	4.4	11.7
07 40 –07 50	90.8	2.2	1.9	4.1	12.4
07 50 –08 00	92.9	2.8	2.2	5.0	15.5
08 00 –08 10	94.4	2.6	2.1	4.7	14.8
08 10 –08 20	93.7	2.8	2.1	4.9	15.3
08 20 –08 30	84.9	3.1	2.4	5.5	15.6
08 30 –08 40	91.5	3.2	2.4	5.6	17.1
08 40 –08 50	72.6	3.2	2.5	5.7	13.8
08 50 –09 00	61.7	3.2	2.5	5.7	11.7
09 00 –09 10	85.7	3.2	2.5	5.7	16.3
09 10 –09 20	69.0	3.2	2.5	5.7	13.1
09 20 –09 30	63.9	3.2	2.5	5.7	12.1
09 30 –09 40	71.1	3.7	2.5	6.2	14.7
09 40 –09 50	81.4	3.4	2.2	5.6	15.2
09 50 –10 00	79.1	...	...	...	....
10 00 –10 10[b]	84.9	3.2	2.2	5.4	15.3
10 10 –10 20	83.5	...	...	...	....
10 20 –10 30[b]	94.4	3.0	2.2	5.2	16.4
10 30 –10 40	87.1	...	...	...	....
10 40 –10 50[b]	95.1	2.8	2.2	5.0	15.8
10 50 –11 00[b]	90.8	2.8	2.2	5.0	15.1
11 00 –12 00	72.6	2.7	2.3	5.0	12.1
12 00 –13 00	66.8	3.1	2.9	6.0	13.3

[a]Air-earth current-density, $i = P(\lambda_+ + \lambda_-)/3 \times 10^4$.
[b]Interpolated values.

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HUANCAYO MAGNETIC OBSERVATORY,
Huancayo, Peru, March 22, 1944

DISCUSSION OF "ATMOSPHERIC-ELECTRIC OBSERVATIONS AT HUANCAYO, PERU, DURING THE SOLAR ECLIPSE, JANUARY 25, 1944"

By O. H. Gish

The correlation, reported by Jones and Giesecke, between certain variations in atmospheric-electric elements, and the progress of the solar eclipse, appears to be more significant than any seen by the writer, in similar observations made elsewhere during solar eclipses [see 1, 2, 3, 4 of "References" at end of paper] except the observations [1] made at Lakin, Kansas, during the eclipse of June 8, 1918, which show effects that appear to have about the same significance. A comparison of the eclipse-effects indicated at these two places derives some of its interest from the fact that the "normal" diurnal variation of potential-gradient and that of air-conductivity at Lakin seems to be of about the same character as that found for the respective elements at Huancayo on most fair-weather days, namely, values of air-conductivity are conspicuously larger at night than in daylight, while the values of potential gradient are larger in daylight and small at night and at both places the diurnal variation of air-earth current is apparently free from this local time-component. Although the data bearing on diurnal variation, obtained at Lakin, Kansas, consist of manual observations for one 24-hour period only, confidence in the indicated character of diurnal variation is strengthened by the fact that the four independently measured elements, namely, potential-gradient, positive conductivity, negative conductivity, and positive ion-concentration, all show the pronounced and consistent difference between daylight and night.

Meteorological conditions reported for the period of observations at Lakin are favorable for the development there of a stable stratum of air adjacent to the Earth at night. The latter is an important feature in the mechanism proposed by the writer [5] to explain the remarkable local aspect of diurnal variation in the several elements at Huancayo and it accordingly seems likely that the diurnal variation observed at Lakin is also attributable to such a mechanism. One may therefore expect an eclipse of the Sun to affect the atmospheric-electric elements in a similar manner at the two places, namely, tend to establish, during the eclipse, values which are characteristic of night.

It may be questioned whether the duration of an eclipse is sufficient to establish the stable air-stratum, but perhaps the time of day was favorable for this at both places. At Huancayo the eclipse started in the morning soon after the supposed stable stratum usually breaks up and at Lakin it ended in the evening shortly before the stable stratum normally begins to form.

According to this view the correlation of the atmospheric-electric elements with the progress of an eclipse, probably indicated in these two cases, is doubtless dependent upon rather restricted local circumstances, not only circumstances which, during the eclipse and normally

at night, are favorable for the formation of the stable air-stratum adjacent to the Earth, but also it seems requisite that Aitken nuclei, apparently supplied to the surface-air in considerable concentration when turbulent mixing prevails, are brought to the station by the higher more general air-circulation. It would then follow that when a stable stratum of air is established at the surface, the concentration of nuclei in the surface-air would diminish, the conductivity would increase, and potential-gradient decrease.

Earlier observations of atmospheric-electric elements during solar eclipses were apparently prompted by the expectation of finding effects which would help in gaining an understanding of the more fundamental aspects of atmospheric electricity. Most of these were made prior to the discovery that the only universal aspect of the diurnal variation in potential-gradient is one in which the variation follows a universal, rather than a local time-schedule. From the fact that over the oceans the diurnal variation is almost wholly of this character, we conclude that solar radiation effects only minor modifications of the atmospheric-electric elements in the troposphere except in special circumstances. Since that discovery other facts and principles have become recognized which dissuade one from expecting important modifications in the atmospheric-electric elements during a solar eclipse except in the air rather near the Earth's surface and that only if the weather and topography of a region, and apparently some additional factors, are favorable. Although marked changes in the electric properties of the high atmosphere (ionosphere) are produced by solar radiation, as is revealed by phenomena of radio transmission, of geomagnetism, and of geoelectricity (earth-currents), no definite correlation between these changes and changes in the elements of atmospheric electricity near the Earth has yet been found [6, 7]. Neither do the atmospheric-electric observations made at times of solar eclipses show convincing evidence of a close relationship with solar activity.

Effects like those apparently manifested at Huancayo, Peru, during the recent eclipse and at Lakin, Kansas, during the eclipse of 1918, despite their dependence upon restricted local conditions, are, however, of interest because a study of them leads to a better conception of the factors which produce departures from the universal component of diurnal variation in potential-gradient, and, to a lesser extent, in air-earth current.

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FRANCIS JOHN WELSH WHIPPLE, 1876-1943

By G. C. Simpson

Dr. Francis John Welsh Whipple, whose death at the age of 67 years occurred on September 25, 1943, was primarily a mathematician and as an undergraduate took a very high place in the Mathematical School at Cambridge. After a short period as mathematical master at one of Britain's best known public schools, where he himself had been trained as a boy, he entered the London Meteorological Office in 1912. For 13 years his work was mainly concerned with meteorological instruments and climatology; but on the retirement of Dr. Charles Chree, Whipple was appointed to succeed him as Superintendent of Kew Observatory, a position held by his father 50 years previously.

Whipple was highly qualified for his new position: his scientific ability and knowledge were of the highest order, and he possessed, what is lacking in so many first-rate scientists, interest in other people's work and readiness to devote his own time and thought to their problems. It is therefore not surprising that under his lead the scientific work at Kew Observatory was expanded and his staff of young men produced an outturn of scientific work which is memorable in the history of even such a celebrated Observatory as Kew.

Unfortunately Whipple was more interested in general scientific problems than in any one special subject, in consequence his name is not associated with any well-known scientific advancement; but he made valuable contributions to meteorology, seismology, and atmospheric electricity which have been of great use to other workers. He made an outstanding investigation into the time of travel of sound-waves through the upper atmosphere, from which much valuable information as to the temperature in the upper stratosphere, beyond the reach of balloons, was obtained. He wrote several papers on atmospheric electricity, the most important of which was probably his paper on the world-wide daily oscillation of potential-gradient, discovered by Mauchly, in which he showed that the curve of daily activity of thunderstorms when summed over the world as a whole gives a close fit to the curve of potential-gradient both in form and phase. As all work on terrestrial magnetism ceased at Kew when Dr. Chree retired, disturbance due to electrical trains having made accurate observations there practically impossible, Whipple had no opportunity of doing work in that science; but he was greatly interested in it especially in its relation to atmospheric electricity.

Whipple attended several meetings of the International Union of Geodesy and Geophysics and was present at the meeting in Washington when the war broke out. His forthright, even blunt, way of expressing his opinions will be remembered by many who heard him speak at those meetings. Sometimes his manner was misunderstood; but all those who knew Whipple intimately knew that it was due to straightforward simplicity and never to a dominating spirit. If Whipple thought a thing

was wrong he said so and that anyone might be hurt never entered his head.

In some ways it is regrettable that Whipple did not concentrate more; but if he had he would not have been such a successful Director of Kew Observatory and that is his chief claim to be remembered by all geophysicists.

List of some of Whipple's publications on atmospheric electricity[1]

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Air Ministry, Meteorological Office,
London, England, February 11, 1944

[1]This brief list added by the Editor.

REVIEWS AND ABSTRACTS

J. BARTELS: *Fluctuations of solar radiation, from the viewpoint of terrestrial magnetism.* Hochfrequenztech., Leipzig, **62**, No. 1, 25-26 (1943). [Summary of a 59-page Prussian Academy paper under the same title as the short survey.]

In an earlier paper, in English (Terr. Mag., **45**, 339-343) the writer states: "In that part of the solar radiation which is absorbed in the ionosphere, and which therefore cannot be observed directly at the ground, the variations in time of the Earth's magnetic field enable one to distinguish two types, which will be referred to as W and P. W ionizes the daytime side of the ionosphere, and is presumably a wave radiation; P consists of corpuscles (particles) which are, at any rate in part, electrically charged and, being deflected by the Earth's magnetic field, penetrate particularly into the auroral zones and reach the night side of the ionosphere." W displays itself most clearly in the quiet-day magnetic variations S_q and L_q; P produces the magnetic disturbances D. The aim of the present exhaustive work is to derive from geomagnetic records, two homogeneous series stretching over many years (actually back to 1872) for W and P, and to compare these with direct solar observations (namely the Zürich relative sunspot-numbers, R), in order to derive a relation between the variations δW of W, and also between the variations δP of P, and the variations δR of R. "As Figure 1 shows, the relations are linear, provided that the quantities δW, δP, and δR are expressed in a suitable way ('normalized'). Thus from the magnetically determined values of δW one can draw conclusions as to the variations of the wave radiation, and from the magnetically measured disturbances δP conclusions as to the variations of the corpuscular radiation."

Regarding the relation between δW and δR, the writer remarks that it is the closest of any hitherto found between any phenomenon on the Sun, expressed in monthly or yearly means, and a similarly expressed phenomenon on the Earth. He considers that δW is a more faithful measure for the variations of the wave radiation than δR itself, especially at sunspot-minima. For the corpuscular radiation P, he points out, the Potsdam "reduced" three-hourly characteristic numbers constitute a specially useful measure. They were introduced by the writer into the practice of geomagnetic research and were adopted for all observations by the International Association of Terrestrial Magnetism and Electricity at its assembly in 1939.

Courtesy *Wireless Engineer* [**21**, 132 (1944)]

Gyro flux gate compass, Automotive and Aviation Industries, **89**, No. 9 (1944).

An entirely new type of compass is in production at the Philadelphia Division of Bendix Aviation Corporation. Developed in the research laboratories of the Eclipse-Pioneer Division of the Corporation, the new device is said to be as great an advance over the conventional magnetic compass as that compass over the lodestone.

This gyro flux gate compass, as the new compass is known, uses the Earth's magnetic field to develop minute electrical impulses which, when amplified, turn the compass-indicator.

This new compass will not go off its reading when the plane dives or climbs rapidly, it will not lag or overshoot during a turn, and it will not oscillate or "hunt" back and forth in rough weather.

An advantage of the new compass is that no "correction-card," necessary with magnetic types, is needed because it gives fully corrected readings at all times. The possibility of the navigator or pilot making an error in the heat of battle is thus eliminated.

Because it is possible to locate the transmitter of this new compass at a distance from the indicating dial, it is possible to find a position for it where it will not be affected by the bomb load, armor plate, or other metal parts that impair the accuracy of the standard compass. Additional indicators are linked to the compass through the medium of the Pioneer "magnesyn" system. This system makes possible remote readings of indications or measurements received from a remote source or master.

R. H. O. [in J. Frank. Inst., **237**, 320-321 (1944)]

H. W. Newton: *Solar flares and magnetic storms.* London, Mon. Not. R. Astr. Soc., **103**, No. 5, 244-257 (1943).

Data on specially intense solar flares from spectroscopic records (including recent spectrohelioscope observations) have been discussed in connection with the occurrence of magnetic storms. Certain features, including their great area and possible characteristics of spectrum, distinguish these very intense flares when they occur. Future observations should aim at including quantitative data to serve as an index of intensity. A geophysical measure of intensity should also be explored.

Far more often than could occur by chance, an intense flare is followed about a day later by a great magnetic storm, provided that the flare is not farther than about 45° from the center of the disk. Assuming that a corpuscular stream is newly ejected at the time and place of an intense solar flare, the mean effective time of travel of the stream from Sun to Earth is about 26 hours, and most intense magnetic storms giving a shorter travel-time of about 20 hours. The distribution on the Sun's disk of flares preceding great magnetic storms is examined and suggests certain features of the corpuscular streams involved.

Author

René Bernard. *Atomic nitrogen in the high atmosphere.* Annales d'astrophysique, **4**, 13-29 (1942).

The author shows that the auroral transition $^4S-^2P$ of $[N\ I]$ ($\lambda 3466.5$) is absent in the night sky but that it is present in the aurora. The author describes the results of his photometric measurements of the intensities of the $[O\ I]$, $[N\ I]$, and N_2 transitions at the base and the summit of the aurora: $\lambda 3466.5$ behaves in the aurora as do the green $[O\ I]$ line and the $A \rightarrow X$ bands of N_2. The author tries to explain the "altitude effect" on the $[O\ I]$, $[N\ I]$, and $A \rightarrow X$ transitions by triple collisions: the dissociation of N_2 is considerable in the aurora, increasing with the height in the atmosphere.

From a long controversial discussion concerning the identification of the nebular transitions $^4S-^4D$ of $[N\ I]$ (near $\lambda 5200$) in the aurora and the night sky, the author concludes that these lines are actually absent, in agreement with Nicolet's previously published results. Incidentally, in another paper not available here, Dufay, Gauzit, and Tcheng Mao-Lin[1] announce the observation of the $\lambda 5200$ line in the high atmosphere. Pending detailed information, the reviewer prefers to abstain from any comment concerning this problem.

Courtesy *Astrophysical Journal* [**99**, 116 (1944)]

[1]Pub. Obs. Lyon, **3**, 59 (1941).

(See also page 144)

PROVISIONAL SUNSPOT-NUMBERS FOR JANUARY TO MARCH, 1944

(Dependent alone on observation at Zürich Observatory)

Day	January	February	March
1	7	7	8
2	0*	7*	0
3	0	0	8
4	0	0	7
5	0	0*	0
6	0	0	0*
7	0	0	0*
8	0	0	0
9	0	0	0*
10	0*	0	0
11	0*	0	0
12	0*	0	0
13	0	0	0*
14	0	0	7
15	0	0*	0
16	0	0*	*E* 8[c]
17	0*	0	14
18	0*	0	29[d]
19	0*	0	31
20	0	0*	33[a]*
21	0	0*	27*
22	8[d]	0	36
23	8	0	36
24	8	0	22
25	8	0	14[a]
26	8	0	14
27	13	0	12
28	18	0	12
29	19	..	15
30	9		7
31	8		0*
Means......	3.7	0.5	11.0
No. days....	31	28	31

Mean for quarter, January to March, 1944: 5.2 (90 days).

*Observed at Locarno.
[a]Passage of an average-sized group through the central meridian.
[b]Passage of a large group or spot through the central meridian.
[c]New formation of a group developing into a middle-sized or large center of activity: *E*, on the eastern part of the Sun's disk; *W*, on the western part; *M*, in the central-circle zone.
[d]Entrance of a large or average-sized center of activity on the east limb.

EIDGEN. STERNWARTE,
Zürich, Switzerland

W. BRUNNER

MAGNETIC DATA, CAPE TOWN AND HERMANUS MAGNETIC OBSERVATORIES, 1940-1942

The Cape Town Magnetic Observatory, which was established for the Polar Year 1932-1933, was unsuitable as a permanent observatory owing to magnetic disturbances caused by the electric railways. The observatory, however, continued in operation until the end of 1940, when a new observatory at Hermanus was ready for work.

Table 1 gives the mean yearly values of the magnetic elements at the Magnetic Observatory, Hermanus, for the years 1941 and 1942, and also gives the relation between these and the Cape Town values for the years 1933-1940, which were published in this Journal September 1941, p. 364.

Simultaneous observations were taken at both observatories in 1940, and the continuity is based upon standard measurements and magnetograms.

Table 1—*Mean yearly values of the magnetic elements at the Cape Town and Hermanus Magnetic Observatories as based upon magnetograms for all days, 1940-1942*

Year	Declination		Horizontal intens.	Vertical intens.	Inclination		North intens.	West intens.	Total intens.
	°	′	γ	γ	°	′	γ	γ	γ
				Cape Town Magnetic Observatory					
1940	−24	16.0	14433	−29164	−63	40.2	13158	5932	32540
1941*	−24	13.1	14357	−29061	−63	42.6	13094	5889	32413
				Hermanus Magnetic Observatory					
1940*	−23	54.5	14328	−29352	−63	59.0	13098	5807	32663
1941	−23	51.6	14252	−29249	−64	01.4	13034	5765	32537
1942	−23	48.1	14187	−29153	−64	03.0	12980	5724	32422

*The magnetic values for these years were calculated from observed differences of magnetic elements at the two Observatories.

Magnetic Observatory,
Hermanus, Cape Province, South Africa, December 23, 1943
A. Ogg

FIVE INTERNATIONAL QUIET AND DISTURBED DAYS FOR JULY TO DECEMBER, 1943

Reports of geomagnetic activity for the second half of 1943 have been received from a sufficient number of observatories so that the international quiet and disturbed days can be selected in accordance with the method outlined on pages 219-227 in the December 1943 issue of this Journal. The selection is based on the reports of magnetic character on a scale of 0, 1, and 2 from 35 observatories and of K-indices from 23 observatories.

Month	Quiet					Disturbed				
July	1	14	24	25	29	4	5	6	8	9
August	10	11	22	23	27	8	13	20	30	31
September	7	16	18	20	24	3	26	28	29	30
October	6	14	15	16	18	1	2	3	9	26
November	11	13	14	15	17	19	20	25	26	27
December	6	11	12	13	28	3	16	17	19	20

Department of Terrestrial Magnetism,
Carnegie Institution of Washington,
Washington, D. C., May 12, 1944
H. F. Johnston

RECENT GEOMAGNETIC WORK AND PLANS OF THE DIRECCION DE METEOROLOGIA, GEOFISICA, E HIDROLOGIA, MINISTERIO DE AGRICULTURA, REPUBLICA ARGENTINA

An isogonic map of Argentina was recently published by the Dirección de Meteorología, Geofísica, e Hidrología of the Ministry of Agriculture giving results of the magnetic survey for epoch January 1, 1944. Recent field-work included complete observations at 178 points. We shall soon publish isodynamic maps of horizontal and vertical force and an isoclinic map. We intend now to maintain two parties in the field continuously, which will effect geomagnetic determinations in an increasing number and make possible publication of our magnetic maps at rather regular intervals based upon more widely distributed data. The present international situation prevents the purchase of additional instrumental equipment and reduces available means of transport.

We expect also to resume publication of our monthly and annual reports, which we were obliged to suspend some years ago because of necessary reductions in the budget.

The observatory on New Year's Island has not been in operation for some years. It belonged to our Navy but, because of the difficulty of access, we have decided to establish soon a new observatory in the southern part of Patagonia. We are still studying as to the best location in the southern part of Santa Cruz or on the Fuegian coast. This new station will join the continental observations with those to be made in the future in the antarctic regions. We also plan to complete our net of magnetic observatories by the addition of one to be established about midway between Pilar (Córdoba) and the new observatory in Patagonia, possibly at some point in the Gobernación Rio Negro or Neuquen.

I should be very obliged to have reports of interest in our fields sent to my office in Buenos Aires (Paseo Colón, 31 F).

ALFREDO G. GALMARINI, *Director*

DIRECCION DE METEOROLOGIA, GEOFISICA, E HIDROLOGIA,
Buenos Aires, República Argentina, March 15, 1944

PRINCIPAL MAGNETIC STORMS

SITKA MAGNETIC OBSERVATORY

JANUARY TO MARCH, 1944

(Latitude 57° 03'.0 N., longitude 135° 20'.1 or 9^h 01^m.3 W. of Gr.)

February 7—A brief period of severe disturbance may be said to have had its commencement at about 05^h 30^m GMT, February 7, when slight deviations from an unusually calm condition became noticeable. A single large departure between 09^h and 11^h gave a *K*-index of 7 for that period. At 12^h large-amplitude oscillations began which continued for an hour and then became progressively smaller during the succeeding three hours. A *K*-index of 9 was recorded during the most severe phase.

February 14—Beginning gradually with moderate, irregular variations a short, but rather severe, storm characterized by moderately slow oscillations was recorded from 00^h to 15^h GMT, February 14, with greatest severity between 08^h and 10^h when there occurred a *K*-index of 8. A brilliant auroral display accompanied the storm.

March 26-27—A moderately severe disturbance began slowly about 02^h GMT, March 26, and was characterized by long-period oscillations until 13^h; activity nearly ceased until 23^h 20^m when small rapid oscillations began which soon became superposed on larger variations. Greatest severity occurred between 06^h and 11^h when *K*-indices of 7 were recorded. This storm is unusual among those of recent quarterly periods, being a recurrence of an earlier disturbance.

HAROLD W. PINCKNEY, *Observer-in-Charge*

TUCSON MAGNETIC OBSERVATORY

JANUARY TO MARCH, 1944

(Latitude 32° 14'.8 N., longitude 110° 50'.1 or 7^h 23^m.3 W. of Gr.)

January 10-17—A magnetic storm of moderate intensity, but of long duration, began about 20^h GMT, January 10. There were no outstanding characteristics of the storm other than that of generally rough magnetic weather. The end of the storm was difficult to identify, but the activity became less disturbed about the end of the Greenwich day, January 17.

February 7-8—A moderately severe storm began at 06^h GMT, February 7. The period of greatest activity, characterized chiefly by rather short-period fluctuations of *D* and *H*, was from 12^h, February 7 to 02^h, February 8. The end of the storm appeared to be at about 22^h, February 8. Ranges: *D*, 17'; *H*, 104 gammas.

February 13-14—A brief but moderately severe storm, lasting about 18 hours, began at 21^h GMT, February 13. There was little short-period activity, but fairly large swings in *D* and *H* were observed. Ranges: *D*, 15'; *H*, 107 gammas.

March 26-27—A moderately severe storm began suddenly at $02^h\ 00^m$ GMT, March 26, with an increase of 30 gammas in H during the first five minutes. The period of most intense activity was from 23^h, March 26 until about 09^h, March 27, during which rapid variations of D and H occurred. The storm ended rather abruptly about 13^h, March 27. Ranges: D, 25′; H, 160 gammas; Z, 25 gammas.

J. H. Nelson, *Observer-in-Charge*

Cheltenham Magnetic Observatory

January to March, 1944

(*Latitude 38° 44′.0 N., longitude 76° 50′.5 or $5^h\ 07^m.4$ W. of Gr.*)

January 10—A bay in H in the last three-hour period of January 10, GMT, gave a K-index of 6, and was followed by minor activity for a week or more.

February 13-14—A moderate storm began at about 22.5^h GMT, February 13, and lasted until about 15^h, February 14. Two K-indices of 6, and three of 5, were recorded during the disturbed period. Z was somewhat more disturbed than usual by comparison with the other elements.

March 18-19—An unimportant storm began indefinitely at about 19^h GMT, March 18, and lasted for approximately nine hours. A K-index of 6 was recorded in the first three-hour period of March 19.

March 26-27—A moderate disturbance resulting in three K-indices of 5 began at $02^h\ 00^m$ GMT, March 26, and apparently ended at about 15^h on the same day. But at $23^h\ 12^m$ a more violent disturbance began, lasting until 12^h, March 27. Three more K-indices of 5, and two of 6, were recorded during this period.

John Hershberger, *Observer-in-Charge*

Huancayo Magnetic Observatory

January to March, 1944

(*Latitude 12° 02′.7 S., longitude 75° 20°.4 or $5^h\ 01^m.4$ W. of Gr.*)

February 7—A short magnetic disturbance was recorded beginning at 12^h GMT, February 7. It was ushered in by a decrease of about 150 gammas in H during the first hour and followed by a number of sharp peaks and bays till after 18^h, and then continued for about two hours more in a mild form. D and Z were also noticeably disturbed during the period of activity in H. H was somewhat below normal for the next day. The total range in H was 180 gammas during the disturbed period.

March 26-27—This disturbance began at $02^h\ 00^m$ GMT, March 26, with an increase in H of 28 gammas in five minutes. Small peaks and bays were present during the next nine hours. From $13^h\ 46^m$ to $14^h\ 20^m$, there were sharp oscillations in H and minor ones in D and Z. H sharply decreased 112 gammas at $14^h\ 05^m$ in a period of about one and one-half minutes. Rapid oscillations began again in H at $23^h\ 20^m$, March 26, and continued to the end of the storm at about 07^h, March 27. A large positive bay from $03^h\ 09^m$ to $05^h\ 51^m$, March 27, gave a K-index of 6.

Paul G. Ledig, *Observer-in-Charge*

Watheroo Magnetic Observatory

January to March, 1944

(Latitude 30° 19′.1 S., longitude 115° 52′.6 or $7^h\ 43^m.5$ E. of Gr.)

February 7-8—This small disturbance began at about 05^h GMT, February 7. There was no sudden commencement, but the traces gradually became more disturbed, reaching their greatest activity at $12^h\ 50^m$ when there were large peaks in D and Z and a considerable bay in H until $13^h\ 26^m$. During this interval the range in H was 103 gammas, in D 11′.5, and in Z 99 gammas. There was a smaller series of peaks and bays between 15^h and $16^h\ 30^m$; however apart from this feature the disturbance gradually subsided until normal conditions again prevailed at 24^h February 8. Ranges: D, 20′.0; H, 113 gammas; Z, 147 gammas.

March 26-27—At $02^h\ 00^m$ GMT, March 26, there was a fairly rapid but small movement which may have marked the commencement of the storm, although it does not possess the usual features of a sudden commencement. Only slight variations from normal values were recorded for the next nine hours; between $11^h\ 30^m$ and $14^h\ 30^m$ there was a series of peaks and bays in all three elements after which there was a quiet period lasting eight hours. At $23^h\ 19^m$ very rapid motions began in D, H, and Z which lasted until 07^h March 27. The mean hourly values of the elements did not depart markedly from normal during this period; however there was continuous and rapid motion and H was slightly lower than usual. During the following nine hours the movements became more leisurely and the disturbance subsided by 16^h March 27. Ranges: D, 19′.5; H, 154 gammas; Z, 114 gammas.

W. C. Parkinson, *Observer-in-Charge*

Hermanus Magnetic Observatory

October to December, 1943

(Latitude 34° 25′.2 S., longitude 19° 13′.5 or $1^h\ 16^m.9$ E. of Gr.)

October 1-5—The disturbances which began at midday of Greenwich date September 26 continued until midday October 5. During the period from October 1 to October 5 the maximum K-index was 5 for each of the three-hour periods 12^h-15^h, October 1, and 12^h-15^h and 18^h-21^h, October 2.

October 7-13—A gradual-commencement disturbance which began at about $06^h\ 30^m$ GMT, October 7, continued until 03^h, October 13. The maximum K-index during this period was 5 for each of the three-hour periods 09^h-12^h and 21^h-24^h, October 8, and 18^h-21^h, October 9.

October 16—Micropulsations on all traces began at 21^h GMT, October 16, and continued for about an hour.

October 20—The K-index was 5 for each of the two three-hour periods from 15^h-21^h, October 20.

October 22-November 1—Gradual-commencement disturbances which began at about $06^h\ 30^m$ GMT, October 22, continued until 03^h, November 1. During this time the maximum K-index was 5 for each of

the following three-hour periods: 09^h-12^h, October 22; 09^h-15^h and 18^h-21^h, October 24; 15^h-21^h, October 26; 18^h-21^h, October 28; 18^h-21^h, October 29; 12^h-15^h, October 30; 12^h-15^h and 18^h-21^h, October 31. The greatest range in H was 113 gammas on October 26.

November 4-8—Disturbances which began at about 13^h GMT, November 4, continued until 03^h, November 8. The maximum K-index was 6 for the three-hour period 15^h-18^h, November 6. The K-index was 5 for the periods 21^h-24^h, November 6, and 09^h-12^h, November 7.

November 12-16—There were micropulsations on all traces from 19^h to $19^h\ 30^m$ GMT, November 12, from $17^h\ 40^m$ to $18^h\ 00^m$, November 14, and from $01^h\ 50^m$ to $02^h\ 40^m$, November 16.

November 18-19—Disturbances which began fairly abruptly at $13^h\ 21^m$ GMT, November 18, continued until 21^h, November 29. There were many micropulsations from 03^h to 16^h, November 19, and the disturbances during this period were very oscillatory. The maximum K-index was 6 for the three-hour period 09^h-12^h, November 19. The K-index was 5 for each of the following three-hour periods: 06^h-09^h, 12^h-15^h, and 21^h-24^h, November 19; 00^h-03^h and 15^h-21^h, November 21; 12^h-15^h and 21^h-24^h, November 23; 18^h-21^h, November 25; 12^h-24^h, November 26.

December 1-5—A gradual-commencement disturbance began at about 12^h GMT, December 1, and continued until 21^h, December 5. The maximum K-index was 5 in each of the three-hour periods 15^h-21^h, December 2, and 18^h-21^h, December 3.

December 15-26—Gradual-commencement disturbances which began at about 09^h GMT, December 15, continued until 22^h, December 26. The disturbances were not of large range but were very oscillatory. The maximum K-index was 5 for each of the three-hour periods 15^h-21^h, December 19. There were micropulsations from $02^h\ 35^m$ to $03^h\ 00^m$ and from $03^h\ 35^m$ to $04^h\ 00^m$, December 25.

December 29—There were micropulsations on all traces from $02^h\ 15^m$ to $03^h\ 00^m$ GMT, December 29. The D-pulsations were the strongest.

A. Ogg, *Magnetic-Survey Adviser*

Apia Observatory

January to March, 1944

(Latitude 13° 48′.4 S., longitude 171° 46′.5 or $11^h\ 27.1^m$ W. of Gr.)

February 13-14—H became disturbed at $23^h\ 00^m$ GMT, February 13. A maximum was reached at $00^h\ 19^m$, February 14, and decreased steadily to a minimum at $07^h\ 05^m$. After this the intensity increased with fluctuations to $14^h\ 06^m$, when the trace became normal. D and Z were slightly disturbed. Range in H was 155 gammas.

March 26-27—H became disturbed at $23^h\ 06^m$ GMT, March 26, and continued so until $12^h\ 03^m$, March 27. The maximum in H was reached at $23^h\ 09^m$, March 26, and the minimum at $06^h\ 00^m$, March 27. Z was disturbed over the same period with a minimum at $00^h\ 36^m$, March 27, and a maximum at $09^h\ 27^m$, March 27. Ranges: H, 146 gammas; Z, 34 gammas.

H. Bruce Sapsford, *Acting Director*

NOTES

12. *Melbourne Observatory*—The control of the Melbourne Observatory (including the Toolangi Magnetic Observatory) has been transferred (March 8, 1944) to the Commonwealth Government, and has been placed under Dr. *R. v. d. R. Woolley*, Director of the Commonwealth Solar Observatory at Canberra. Dr. *J. M. Baldwin*, although already past the normal age of retirement, will continue as Officer-in-Charge of the Melbourne Observatory for another year.

13. *Sever Institute of Geophysical Technology*—We learn from *Science* that, by the will of Henry Edward Sever, the Chicago publisher, St. Louis University will receive the sum of $3,318,000. According to the daily press, Judge Joseph A. Graber, of the Cook County Superior Court, was directed to select a university or college in Missouri and award to it $100,000, plus whatever remained in the estate after the bequests had been made. Four institutions were surveyed by a committee of three members—Kansas City University, Washington University, University of Missouri, and St. Louis University. It was directed that the bequest be used for the founding of a technological institute to bear the name of the donor. Doubtless, a large factor in the decision to make the award to the St. Louis University was the work of Rev. James B. Macelwane, S.J., who founded the University's Department of Geophysics 19 years ago and whose seismological investigations have won international renown. The new Sever Institute of Geophysical Technology is to be devoted exclusively to geophysics to fit men to meet some of the most acute postwar needs. Courses will be given in scientific exploration for oil and minerals to replace war-depleted reserves, meteorology, applied electronics, and radio-communications engineering.

14. *Chinese Physical Society*—The Chinese Physical Society was organized in 1932 with the intention of holding annual meetings and publishing the *Chinese Journal of Physics* in which articles were to be written in English, French, and German with abstracts in Chinese. A number of annual meetings were held jointly with those of the Science Society of China. In 1942, however, when communication had become difficult and expensive, it was decided that there should be six centers for sectional meetings. Actually meetings were held in Kunming, Chungking, Chengtu, and Kweilin. Altogether some 70 papers were presented, among which were the following titles: Electromagnet and cloud chambers designed for the investigation of cosmic rays of very high energies; A new high-tension supply for Geiger-Müller counters; Results of magnetic observations at Chungan, Fukien, during the total eclipse of September 21, 1941; and Heat treatment of permanent magnet steels.

15. *Honolulu Observatory*—Difficulty is being experienced in keeping the Honolulu Observatory of the Coast and Geodetic Survey in operation.

The military planes often fly so close as to throw the variometers out of adjustment and interfere with absolute observations.

16. *Witteveen Magnetic Observatory*—From information received from the Secretary of the International Meteorological Organization, Lausanne, Switzerland, we regret to state that the Magnetic Observatory at Witteveen, Holland, has had to discontinue the supply of magnetic character-figures on a scale of 0, 1, and 2 and of K-indices at the end of March 1943.

17. *Magnetic surveys of American Republics*—Two magnetic field-parties of the United States Coast and Geodetic Survey are continuing a program of repeat-observations in Central and South America in cooperation with the American Republics. *Nathan O. Parker* has completed work in Panama, Costa Rica, and in Honduras, and was last reported in Guatemala in May. *Joel B. Campbell* has completed observations as far south as Punta Arenas in Chile and is next scheduled to go to the Juan Fernandes Islands.

The United States Coast and Geodetic Survey is engaged upon its program of obtaining magnetic repeat-observations in the United States preparatory to the compilation of the isogonic chart for 1945. *Fred Keller, Jr.*, has completed a field-trip through the southern portion of the country and *William E. Wiles* and *C. Edward Westerman* are each making field-trips through the central and western States.

18. *Magnetic publications*—The United States Coast and Geodetic Survey has in press the magnetic observatory results for the Honolulu Magnetic Observatory, 1935-36. The results for the Tucson Magnetic Observatory, 1933-34, and the Sitka Magnetic Observatory, 1935-36, have been released.

19. *American Geophysical Union*—The twenty-fifth annual meetings of the American Geophysical Union, the membership of which now exceeds 2,100, and of its eight Sections, were held in the Hall of Government of the George Washington University, Washington, D. C., June 1 and 2, 1944.

At the evening session of the Union, held on June 2, 1944, an address of welcome was delivered by President Cloyd Heck Marvin, of the George Washington University. This was followed by the address of the Retiring President of the Union, Dr. W. C. Lowdermilk, who spoke on the subject "Down to Earth." At this session the sixth award of the William Bowie Medal was made to Henry Bryant Bigelow, the citation being given by Rear-Admiral L. O. Colbert.

At the sessions of the Sections of the Union, well over 120 scientific papers and reports were presented—an indication of the surprising activity in geophysics when so many members of the Union are engaged in researches connected with the war and which may not now be communicated at public meetings. In some of the Sections the number of papers given exceeded that of previous years. This was especially true in the case of the Section of Meteorology, which was obliged to arrange for an extra session to accommodate papers submitted in excess of the number expected.

The papers presented in the Section of Terrestrial Magnetism and Electricity covered a large range of subjects, including the geographic

coincidence of aurora and geomagnetic disturbance in the Northern Hemisphere, relation of the three-hour-range index K to auroras at Ithaca, New York, auroral photogrammetry, curiosities of magnetographs, analysis of magnetometer-deflections, magnetic properties of sediments, magnetic survey of the Canon City (Colorado) area, results of observations taken to detect an inter-solar calcium cloud during a magnetic storm, secular change in vertical intensity at Huancayo Magnetic Observatory, radon-content of soil gas, theories regarding electrical aspects of thunderstorms, new development of the potential-drop method of electrical prospecting, short-time periodicities in terrestrial magnetism, and progress reports on the geomagnetic and geoelectric researches at the Department of Terrestrial Magnetism of the Carnegie Institution of Washington, and on the magnetic work of the United States Coast and Geodetic Survey.

20. *Erratum*—The following correction is to be made in the paper by A. Duperier on page 6 of the March 1944 issue of the JOURNAL: In the eleventh last line read "$\mu=2.28$ per cent" for "$\mu=22.8$ per cent."

21. *Personalia*—At the meeting of the National Academy of Sciences held April 25, 1944, the two following geophysicists were elected members: Dr. *James Bernard Macelwane*, S.J., Director of the Department of Geophysics and Dean of the Graduate School, University of St. Louis, and Dr. *Louis Byrne Slichter*, Professor of Geophysics, Massachusetts Institute of Technology.

Robert E. Gebhardt rejoined the staff of the Coast and Geodetic Survey in April; at the present time he is in the Washington Office assisting *H. E. McComb*, Chief of the Section of Operations.

We learn from Earthquake Notes that Rev. *S. Sarasola*, S.J., has been transferred from Bogotá, Colombia, to Havana, Cuba, to become Director of the Belem Observatory.

Sir *Charles Vernon Boys*, physicist of Andover, England, died April 2, 1944, at the age of 89 years. He is known to readers of the JOURNAL for his studies of lightning and for the camera he devised for these investigations.

LIST OF RECENT PUBLICATIONS

By H. D. Harradon

A—Terrestrial and Cosmical Magnetism

Afrique Occidentale Française. Service Météorologique. Memento du Service Météorologique. No. 9. Notes sur la géophysique. Publié sous la direction de L. Welter. Rufisque, Imprimerie du Gouvernement Général, 1943, 96 pp. 27 cm. [Contains sections dealing with terrestrial magnetism and atmospheric electricity with special reference to French West Africa.]

Chapman, S. A theoretical note on the magnetic field of a circular sunspot. Terr. Mag., **49**, No. 1, 37-42 (1944).

Coimbra. Observações meteorológicas, magnéticas e sismológicas feitas no Instituto Geofísico (Observatorio meteorológico, magnético e sismológico) no ano de 1938. 2ª parte—Magnetismo terrestre. Vol. LXXVII. Coimbra, Tip. da Gráfica de Coimbra, 30 pp. (1940).

Observações meteorológicas, magnéticas e sismológicas feitas no Instituto Geofísico (Observatorio meteorológico, magnético e sismológico) no ano de 1939. 2ª parte—Magnetismo terrestre, Vol. LXXVIII. Coimbra, Tip. da Gráfica de Coimbra, 22 pp. (1942).

Fleming, J. A., and W. E. Scott. List of geomagnetic observatories and thesaurus of values—IV. Terr. Mag., **49**, No. 1, 47-52 (1944).

Harrison, E. P., and E. H. Smith. A new method of measuring the inclination of the Earth's magnetic field. London, Proc. Phys. Soc., **56**, No. 313, 31-47 (1944).

Hurwitz, L., and H. H. Howe. Magnetic observatory results at San Juan, Puerto Rico, for 1926-28. Washington, D. C., U. S. Coast Geod. Surv., 137 pp. (1943). 25 cm.

Johnston, H. F. American magnetic character-figure, C_A, three-hour-range indices, K, and mean K indices, K_A, for October to December, 1943, and summary for year 1943. Terr. Mag., **49**, No. 1, 53-61 (1944).

Preliminary magnetic character-figures, C, for 1942 and lists of five selected quiet and disturbed days for January to June, 1943. Terr. Mag., **49**, No. 1, 62-63 (1944).

Knapp, D. G., and H. H. Howe. Magnetic observatory results at Tucson, Arizona, for 1933-34. Washington, D. C., U. S. Coast Geod. Surv., 116 pp. (1943). 25 cm.

Magnetic observatory results at Sitka, Alaska, for 1935-36. Washington, D. C., U. S. Coast Geod. Surv., 122 pp. (1944). 25 cm.

Magnetic observatory results at Cheltenham, Maryland, for 1933-34. Washington, D. C., U. S. Coast Geod. Surv., 117 pp. (1943). 25 cm.

Nettleton, L. L., and T. A. Elkins. Association of magnetic and density contrasts with igneous rock classification. Geophysics, **9**, 60-78 (1944).

Newton, H. W. Solar flares and magnetic storms. Mon. Not. R. Astr. Soc., **103**, No. 5, 244-257 (1943).

Principal Magnetic Storms. Principal magnetic storms, October to December, 1943. Terr. Mag., **49**, No. 1, 65-68 (1944). [Storms reported for Apia Observatory and for the Magnetic Observatory, Hermanus, are for July to September, 1943.]

Rio de Janeiro, Observatorio Nacional. Boletim magnético do Observatorio Nacional 1935 à 1939. Rio de Janeiro, Imprensa Nacional, 201 pp. (1942). 33 cm. [Results of registrations at the Vassouras Magnetic Observatory 1935 to 1939 inclusive.]

Rio de Janeiro, Observatorio Nacional. Boletim magnético do Observatorio Nacional 1940 e 1941. Rio de Janeiro, Imprensa Nacional, 85 pp. (1944). 33 cm. [Results of registrations at the Vassouras Magnetic Observatory 1940 and 1941.]

Wantland, D. Magnetic interpretation. Geophysics, **9**, No. 1, 47-59 (1944). [It is common knowledge that magnetic anomalies do not always correspond to structural uplifts. The author discusses this problem under the headings of: (1) Examples; (2) The magnetic character of sediments; (3) Possibilities of magnetic stratigraphic studies; (4) The place of magnetic surveying.]

B—Terrestrial and Cosmical Electricity

Aharoni, J. Effect of space charge on electron beams. Phil. Mag., **35**, No. 240, 36-50 (1944).

Beach, A. The aurora. Astr. Soc. Pacific Leaflet No. 180, 8 pp. (Feb. 1944).

Dudley, L. P. Lightning and kindred phenomena. Electrician, London, **129**, 507-510 (1943).

Duperier, A. A new cosmic-ray recorder and the air-absorption and decay of particles. Terr. Mag., **49**, No. 1, 1-7 (1944).

Fehér, D. Untersuchungen über die biologische Wirkung der durchdringenden Strahlung der Elemente. Sonderabdruck aus "Erdészeti Kisérletek," Sopron (Ungarn), **44**, 39 mit 42 Abb. (1943).

Fessenkoff, B., and N. Parijskij. On the origin of cosmic rays and on the mean life-time of atoms. Moscou, C.-R. Acad. sci., **39**, No. 5, 184-186 (1943).

Findeisen, W. Ueber die Entstehung der Gewitterelektrizität. Met. Zs., **57**, 201-215 (1940).

Flowers, J. W. Lightning. Measuring lightning current photographically. Experiment, procedure, and examples of results. Gen. Elec. Rev., **47**, No. 4, 9-15 (1944).

Forrest, J. S. The determination of the location and frequency of thunderstorms by a radio method. Q. J. R. Met Soc., **69**, No. 298, 33-44 (1943). Discussion, pp. 45-46. [It is concluded that the method of thunderstorm-recording described should find useful application in cases where it is desired to obtain (a) an indication of the presence of a storm within a radius of a few hundred kilometers of the recorder, (b) an approximate measure of the distance of the storm from the recorder, (c) several hours' warning of the possible outbreak of a storm in the locality of the recorder, and (d) statistical data on thunderstorm frequency.]

Hazen, W. E. Cascade showers and nuclear disintegrations at 10,000 feet. Phys. Rev., **65**, Nos. 3 and 4, 67-75 (1944).

The average specific ionization of the mesotrons 100 ft. underground. Abstract, Phys. Rev., **65**, Nos. 3 and 4, 152 (1944).

Heitler, W., and H. W. Peng. On the production of mesons by proton-proton collisions. Proc. R. Irish Acad., A, **49**, 101-133 (1943).

Iona, M., Jr., M. Schein, and J. Tabin. Secondary radiation produced by cosmic-ray primaries in paraffin. Abstract, Phys. Rev., **65**, Nos. 1 and 2, 64 (1944).

Kolhörster, W. Harte und weiche Höhenstrahlen bei magnetischen Stürmen. Phys. Zs., **44**, 48 (1943).

Kornfeld, J. A. Electrical logging through thick salt zone. Petrol. Eng., Dallas, Tex., **14**, No. 12, 90-94 (1943).

Lange, E. Voltapotentiale an H_2O—Phasen als Quelle der Gewitterelektrizität. Met. Zs., **57**, 429-436 (1940).

Lapp, R. E. The origin of large cosmic-ray bursts. Abstract, Phys. Rev., **65**, Nos. 1 and 2, 63 (1944).

Lasareff, P. P. Études des variations séculaires du magnétisme terrestre II. Les variations séculaires et les anomalies magnétiques locales. Moscou. C.-R. Acad. sci., **27**, No. 9, 937-939 (1940).

LEWIS, L. G., AND E. W. LEWIS. Study of cosmic-ray showers using the method of coincident bursts in two unshielded ionization chambers. Abstract, Phys. Rev., **65**, Nos. 1 and 2, 63 (1944).

LINKE, F. Kondensationskerne im Elektronenmikroskop sichtbar gemacht. Naturwiss., **31**, Heft 19/20, 230-231 (1943).

RUDOLPH, H. Eine neue Gewittertheorie. Met. Zs., **57**, 419-420 (1940).

SAYERS, J. Ionization phenomena in the Earth's atmosphere. London, Phys. Soc., Rep. Prog. Phys., **9**, 52-61 (1943).

SCHEIN, M., AND R. E. LAPP. An analysis of large cosmic-ray bursts. Abstract, Phys. Rev., **65**, Nos. 1 and 2, 63-64 (1944).

STETSON, HARLAN T. On the observational evidence for changes in ionization of the upper atmosphere attributable to the Moon. Terr. Mag., **49**, No. 1, 9-24 (1944).

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SWANN, W. F. G. The nature of cosmic rays—I. Sky and Telescope, **3**, No. 7, 3-6 (1944).

VESTINE, E. H. Preliminary summary, auroral observations, Meanook, Canada, December 1, 1932, to June 30, 1933. Terr. Mag., **49**, No. 1, 25-36 (1944).

WAY, H. J. R. Reef prospecting by the resistivity method in Uganda. Amer. Inst. Min. Metall. Eng., Tech. Pub. No. 1676, 17 pp. (1944).

WILCOX, S. W. Sand and gravel prospecting by the earth-resistivity method. Geophysics, **9**, No. 1, 36-46 (1944). [The four electrode earth-resistivity method is applied to the search for sand and gravel deposits in the glaciated areas of the United States. The technique differentiates between clays and granular material enabling the prospector to outline and roughly estimate the quantities of each without test pits or bore holes. Several examples of field surveys are given.]

C—Miscellaneous

BAGCHI, K. N. The mysteries of dust. Science and Culture, **9**, No. 8, 346-349 (1944). [Lecture delivered before the Rotary Club, Calcutta, November 2, 1943.]

BARAJAS, A. Birkhoff's theory of gravitation and Einstein's theory for weak fields. Proc. Nation. Acad. Sci., **30**, No. 3, 54-57 (1944).

BRANT, A. Aerial geophysical prospecting. Montreal, Canadian Min. Met. Bull., No. 376, 395-396 (1943). [Geophysical exploration can be made from airplanes. The author discusses briefly such a possibility for the magnetic, electromagnetic and gravimetric methods. For each of these methods he outlines: (1) theoretical basis, (2) apparatus, and (3) limitations; further comments are added in two cases.]

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Fessenkoff, V. G. Dynamical theory of the zodiacal light. Astroph. J., **98**, No. 1, 129-130 (1943).

Ghosh, S. N. A comparison of the variations of night-sky luminescence and of region-F electron density at night. Science and Culture, **9**, No. 4, 170-172 (1943).

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Goldhaber, M. Nuclear disintegration produced by cosmic rays. Nature, **153**, 221-222 (Feb. 19, 1943).

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Harradon, H. D. List of recent publications. Terr. Mag., **49**, No. 1, 71-75 (1944).

Heiland, C. A. Geophysics. Oil exploration by geophysical methods active but pools found are smaller. Geophysicists in other fields. Mining and Metallurgy, **25**, No. 446, 61-65 (1944).

Hewson E. W. The reflection, absorption, and transmission of solar radiation by fog and cloud. Q. J. R. Met. Soc., **69**, No. 298, 47-62 (1943).

Hunter, A. Solar physics. London, Phys. Soc., Rep. Prog. Phys., **9**, 101-112 (1943). [Contains chapter on bright chromospheric eruptions and their geophysical effects.]

Jennings, B., C. D. Swartz, and H. H. Rossi. A small pressure-insulated electrostatic generator. Rev. Sci. Instr., **15**, No. 3, 64-68 (1944).

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Massey, H. S. W., and D. R. Bates. The properties of neutral and ionized atomic oxygen and their influence on the upper atmosphere. London, Phys. Soc., Rep. Prog. Phys., **9**, 62-74 (1943).

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RUMRILL, H. B. Sunspots in 1769 and 1943. Pop. Astr., **52**, No. 2, 85-87 (1944).

SCIENCE SERVICE. Science from shipboard. A simple manual of information and instruction for those who cross the seas in ships to fight for freedom. Washington, D. C., Science Service, 1943, 268 pp. 18 cm. [In the chapter devoted to "Navigation" there is a section dealing with "Compass and logs."]

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SHAPLEY, A. H. An estimate of the trend of solar activity, 1944-50. Terr. Mag., **49**, No. 1, 43-45 (1944).

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STUEMPFLE, R. An eclipse report. Sky and Telescope, **3**, No. 5, 3 (1944). [Observation of the solar eclipse of January 25, 1944, in Peru.]

TILTON, E. P. On the very highs. QST, **28**, No. 3, 41-43, 86 (1944). [Contains section on aurora-reflected signals—aurora DX.]

TUSKA, C. D. Historical notes on the determinations of distances by timed radio waves. J. Frank. Inst., **237**, No. 1, 1-20; No. 2, 83-102 (1944). [In this article is traced the history of the measurement of the propagation times of radio waves as a means of determining distance. The text of A. E. Kennelly's original article "On the elevation of the electrically conducting strata of the Earth's atmosphere" in *Electrical World and Engineer* of March 15, 1902, is reproduced. A bibliography of 81 papers is appended.]

UNDERHILL, E. M. Mechanical problems of permanent magnet design. Electronics, **17**, No. 2, 126-129 (1944).

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LETTERS TO EDITOR

(See also page 129)

SOLAR AND MAGNETIC DATA, JANUARY TO MARCH, 1944, MOUNT WILSON OBSERVATORY

The magnetic storm of January 10 to 18, 1944, occurred during a quiescent period on the Sun. No sunspots were observed from January 3 to 18. A very small spot (Mount Wilson No. 7633), seen on that day only, was in the bright calcium flocculi over the region where No. 7631 (which was accompanied by a magnetic storm from December 16 to 21, 1943), had been on the previous rotation of the Sun [see *Terr. Mag.*, **49**, 63 (1944)]. This region had returned to view at the east limb on January 9.

TABLE 1—*Magnetic storms*

Greenwich civil time			Range in H
Beginning		Ending	
1944	*h m*	*d h m*	γ
Jan. 10	22 ..	18 24 ..	100
Feb. 7	6 ..	12 24 ..	100
Feb. 13	21 ..	14 17 ..	105
Mar. 26	1 56*	27 22 ..	160

*Sudden commencement.

During the magnetic storm of February 7 to 12 and that of February 13 to 14, the same region was again on the visible hemisphere of the Sun, having returned to the east limb on February 6. The calcium flocculi over the region were much fainter than in January. No spots were observed from February 2 to 18.

The storm of March 26 to 27 may have been associated with the large sunspot group, No. 7636, which was one day past the central meridian at the beginning of the storm. Its area had decreased 50 per cent since it came around the east limb on March 18. The smaller spot with S polarity was almost due north of the main spot with N polarity.

Fewer data than usual are given in Tables 1 and 2 because the power-lines were down on Mt. Wilson from February 20 to March 26.

TABLE 2—*Solar and magnetic data*

ay	January 1944						February 1944						March 1944	
	K_2 Whole disk	K_2 Central zone	H_α bright	H_α dark	No. groups	Mag'c char.	K_2 Whole disk	K_2 Central zone	H_α bright	H_α dark	No. groups	Mag'c char.	No. groups	Mag'c char.
	1	1	1	1	1	0	..	..	1	1	1	0	..	...
	..	..	..	..	..	0	1	1	1	1	0	0	..	...
	..	..	1	1	0	0	..	..	..	..	..	0	..	...
	..	..	..	..	..	0	..	..	..	..	0	0	..	...
	1	0	1	1	0	0.5	0	0	1	1	0	0	0	...
	0	0	0	1	0	0	0	1	0	1	0	0	0	...
	0	0	0	1	0	0	0	0	0	1	0	1	0	...
	0	0	0	1	0	0	..	..	..	..	..	0.5	0	...
	0	0	0	1	0	0	1	0	1	1	0	0.5	0	...
	..	..	..	..	..	0.5	1	1	1	2	0	0.5	0	...
	1	0	1	1	0	0.5	1	1	1	2	0	0.5	0	...
	1	0	1	0	0	0.5	1	1	1	2	0	0	..	...
	1	1	1	0	0	1	1	1	1	1	0	0	..	...
	1	1	1	0	0	1	1	1	0	1	0	1	1	...
	1	1	1	1	0	1	0	0	0	1	0	0.5	1	...
	1	2	1	1	0	0.5	0	0	0	1	0	0.5	0	...
	..	..	..	..	0	0.5	..	..	..	..	..	0	1	...
	1	1	1	1	1	0.5	0	0	0	1	0	0	2	...
	1	1	1	1	0	0	..	..	..	..	..	0	2	...
	..	..	..	..	0	0	..	..	..	..	..	...	2	...
	1	1	1	1	0	0	..	..	..	..	..	...	2	...
	1	1	1	1	1	0	..	..	..	..	..	...	3	...
	..	..	..	..	1	0	..	..	..	..	..	...	3	...
	..	..	..	..	..	0	..	..	..	..	..	...	3	...
	..	..	..	..	1	0	..	..	..	..	..	...	1	...
	..	..	..	..	1	0	..	..	..	..	..	...	2	1
	..	..	..	..	..	0	..	..	..	..	..	...	1	1
	1	1	1	1	1	0	..	..	..	..	..	...	1	0
	..	..	..	..	..	0	..	..	..	..	0	...	1	0.5
	..	..	..	..	..	0	..	..	..	..	..	...	1	0.5
	..	..	..	..	1	0	..	..	..	..	..	...	0	0
an	0.8	0.6	0.8	0.8	0.3	0.2	0.5	0.5	0.6	1.2	0.1	0.3	1.1	(0.5)

NOTE—For an explanation of these tables see this JOURNAL, 35, 47-49 (1930).

The character-figures of solar pehnomena are estimated from the spectroheliograms which are made with a 2-inch solar image, ally in the early morning. Very bright chromospheric eruptions are reported in these notes if observed at any time during the day.

a, bFormation of a new group which later developed to average size or larger; (a) less than 30° from the center of the disk, (b) more n 30° from the center of the disk.

c, dVery bright chromospheric eruptions; (c) less than 30° from the center of the disk, (d) more than 30° from the center of the :.

e, f, g, h, i, j, k, lPassage of a large or active group across the central meridian within 5°, 10°, 15°, 20°, 25°, 30°, 35°, 40° of the ;er of the disk, respectively.

CARNEGIE INSTITUTION OF WASHINGTON,
MOUNT WILSON OBSERVATORY,
Pasadena, California

SETH B. NICHOLSON
ELIZABETH STERNBERG MULDERS

NOTICE

Some of the early numbers of the Journal *Terrestrial Magnetism and Atmospheric Electricity*, in response to numerous demands, have been reprinted. A few complete unbound sets of Volumes I to XLVIII, therefore, can now be supplied at $151.00 each, postpaid.

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